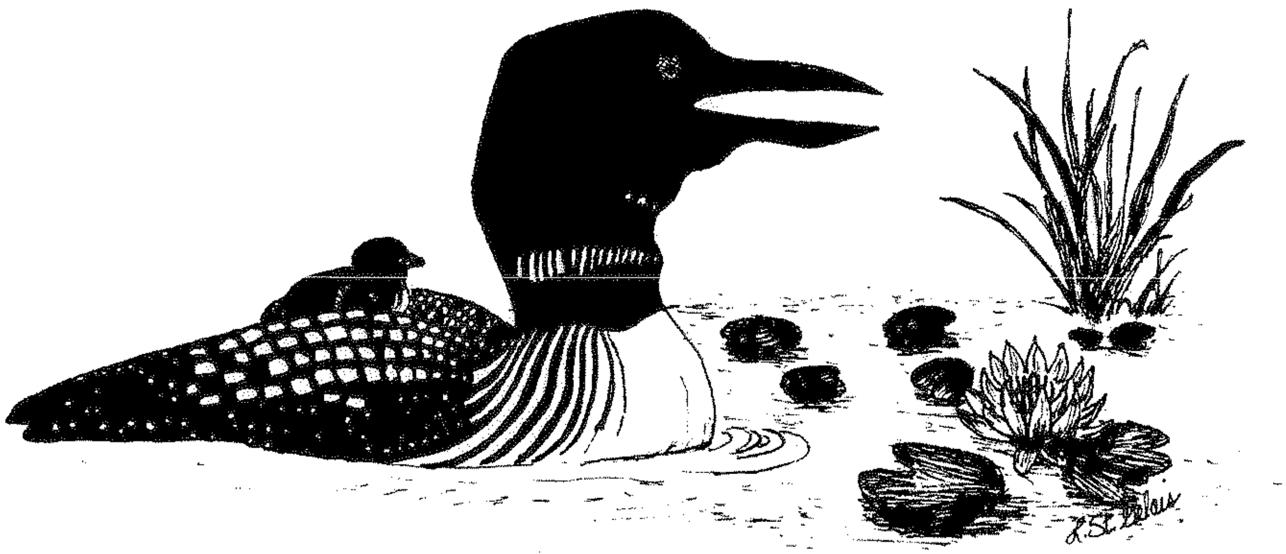
MERRYMEETING LAKE

Water Quality Monitoring: 1999
Summary and Recommendations
NH LAKES LAY MONITORING PROGRAM



By: Robert Craycraft & Jeffrey Schloss

FRESHWATER BIOLOGY GROUP
University of New Hampshire

UNIVERSITY OF NEW HAMPSHIRE COOPERATIVE EXTENSION

To obtain additional information on the NH Lakes Lay Monitoring Program (NH LLMP) contact the Coordinator (Jeff Schloss) at 603-862-3848 or Assistant Coordinator (Bob Craycraft) at 603-862-3546.

PREFACE

This report contains the findings of a water quality survey of Merrymeeting Lake, New Durham New Hampshire, conducted in the summer of 1999 by the University of New Hampshire **Freshwater Biology Group (FBG)** in conjunction with the Merrymeeting Lake Association.

The report is written with the concerned lake resident in mind and contains a brief, non-technical summary of 1999 results as well as more detailed "Introduction" and "Discussion" sections. Graphic display of data is included, in addition to listings of data in appendices, to aid visual perspective.

ACKNOWLEDGMENTS

1999 was the sixteenth year Merrymeeting Lake was monitored in conjunction with the **New Hampshire Lakes Lay Monitoring Program (LLMP)**. The volunteer monitors involved in the water quality monitoring effort are highlighted in Table 1 while William Schmid again coordinated the volunteer monitoring activities on Merrymeeting Lake and acted as liaison to the **Freshwater Biology Group (FBG)**. The **Freshwater Biology Group** congratulates the volunteer monitors on the quality of their work, and the time and effort put forth. We invite other interested residents to join the Merrymeeting Lake water quality monitoring effort in 2000 and expand upon the current database. Funding for the volunteer monitoring program was provided by the Merrymeeting Lake Association and the Town of New Durham.

Table 1: Merrymeeting Lake Volunteer Monitors (1999)

Monitor Name
Ron Kennedy
Bill Schmid
Al Wellman
Marilin Willard

The **Freshwater Biology Group** is a not-for-profit research program co-supervised by Dr. Alan Baker and Dr. James Haney and coordinated by Jeffrey Schloss. Members of the **FBG** summer field team included, Robert Craycraft (laboratory and field team coordinator), Jennifer Lessard, Rachael Olszewski, John Thompson and Jennifer Wishinski while Lindsey Fiske and Stephanie Rizzo provided additional support in the fall. We also acknowledge Nancy Lambert for her assistance in generating digital maps for participating **NH LLMP** lakes.

The **FBG** acknowledges the University of New Hampshire Cooperative Extension for funding and furnishing office and storage space while the College of Life Sciences and Agriculture provided laboratory facilities and additional storage space.

Participating groups in the **LLMP** include: The Center Harbor Bay Conservation Commission, Dublin Garden Club, Eaton Conservation Commission, Governor's Island Club Inc., Laconia Conservation Commission, Meredith Bay Rotary Club, The New Hampshire Audubon Society, North River Lake Water Quality Audit Committee, Society for Protection of Lakes and Streams, Walker's Pond Conservation Society, United Associations of Alton, the associations of Baboosic Lake, Berry Bay, Bow Lake Camp Owners, Chalk Pond, Lake Chocorua, Conner Pond, Cunningham Pond, Crystal Lake, Dublin Lake, Goose Pond, Great East Lake, Lake Kanasatka Watershed, Langdon Cove, Long Island Landowners, Lovell Lake, March's Pond, Mendum's Pond, Merrymeeting Lake, Milton Ponds Lake Lay Monitoring, Mirror Lake (Tuftonboro), Moultonborough Bay, Lake Winnipesaukee, Naticook Lake, Newfound Lake, Nippo Lake, Pemaquid Watershed, Silver Lake (Madison), Silver Lake (Tilton), Squam Lakes, Sunset Lake, Wentworth Lake and the towns of Alton, Amherst, Enfield, Errol, Madison, Meredith, Merrimack, Milan, Strafford and Wolfeboro.

Merrymeeting Lake 1999 Non-Technical Summary

Weekly water quality data were collected by the Merrymeeting Lake volunteer monitors between May 6 and September 20, 1999 while additional water quality measurements were also collected in October and November on a less frequent basis. Supplemental in depth water quality surveys of the Merrymeeting Lake deep sampling stations were conducted by the **Freshwater Biology Group** on August 12 and August 31, 1999 to augment the volunteer monitoring data. Generally speaking, the 1999 Merrymeeting Lake water quality remained excellent as summarized in Table 1. Furthermore, the Merrymeeting Lake water clarity measurements are some of the deeper visibility readings documented in New Hampshire while the levels of microscopic plant growth, measured as chlorophyll *a*, are some of the lower levels documented in our New Hampshire Lakes.

Table 2: 1999 Merrymeeting Lake Seasonal Average Water Quality Readings and Water Quality Classification Criteria used by the New Hampshire Lakes Lay Monitoring Program.

Parameter	Oligotrophic "Pristine"	Mesotrophic "Transitional"	Eutrophic "Enriched"	Merrymeeting Lake Average (range)	Merrymeeting Lake Classification
Water Clarity (meters)	> 4.0	2.5 - 4.0	< 2.5	9.6 meters (range: 7.2 – 13.0)	Oligotrophic
Chlorophyll a (ppb)	< 3.0	3.0 - 7.0	> 7.0	1.6 ppb (range: 0.4 – 2.7)	Oligotrophic
Phosphorus (ppb)	< 15.0	15.0 - 25.0	> 25.0	6.4 ppb (range: 3.6 - 10.8)	Oligotrophic

Note: the summary table excludes data collected in Elly Cove.

1) **Water Clarity (measured as Secchi Disk transparency)** – The 1999 Merrymeeting Lake Secchi Disk transparency data fell well within the range of values considered typical of an unproductive "pristine" New Hampshire Lake but were highly variable between May and November (Figures 10-15). The water transparency measurements were highest (clearest water) during the month of August and followed a period of atypically dry weather that limited the flushing of sediments, "tea" colored water and nutrients into Merrymeeting Lake.

Table 3: 1999 Water Clarity data summary for the Merrymeeting Lake deep sampling stations.

Site	Seasonal Average Water Transparency (meters)
1 Broad Cove	10.5 meters (range: 8.0 – 13.0)
2 Owls Head	9.4 meters (range: 7.7 – 11.0)
3 East End	8.8 meters (range: 7.2 – 11.3)

Comparisons among the 1999 Merrymeeting Lake sampling locations indicate the water transparency measurements declined from the western (Site 1 Broad Cove) to the eastern (Site 3 East End) side of the lake (Table 3). A five-year comparison (1995 to 1999) among the three deep sampling stations also indicates a general decrease in water transparency from the western to eastern side of the lake (Figure 22).

The 1999 Secchi Disk transparency measurements documented at Site 1 Broad Cove remained well within the range of historical values and were similar to the water transparency values documented since 1995 (Figure 16). Likewise, the 1999 Secchi Disk transparency measurements documented at Site 2 Owls Head remained well within the range of historical values, although the water transparency measurements have gradually decline over the past three years (Figure 18). The 1999 seasonal average Secchi Disk transparency of 8.8 meters documented at Site 3 East End is the shallowest value on record and continues a trend of decreasing water transparency over the past four years (Figure 20).

2) Microscopic plant abundance "greenness" (measured as chlorophyll *a*) – The 1999 seasonal chlorophyll *a* concentrations were low at each of the three deep sampling stations and remained below the concentration of 3 parts per billion (ppb) considered the boundary between an unproductive "pristine" and more nutrient enriched "transitional" New Hampshire Lake (Table 4 and Figures 11, 13 and 15).

Table 4: 1999 Chlorophyll *a* data summary for the Merrymeeting Lake deep sampling stations.

Site	Seasonal Average Chlorophyll *a* (ppb)
1 Broad Cove	1.5 ppb (range: 0.9 – 2.5)
2 Owls Head	1.6 ppb (range: 0.8 – 2.3)
3 East End	1.7 ppb (range: 0.4 – 2.7)

The 1999 seasonal chlorophyll *a* concentrations documented in Merrymeeting Lake, Sites 1 Broad Cove and 2 Owls Head, remained within the range of values documented since 1981 while the 1999 seasonal chlorophyll a data collected at Site 3 East End were at the highest level documented since 1995 and exhibit a trend of increasing chlorophyll *a* concentrtions "more algal greeness" (Figures 17, 19, 21 and 23).

***3)* Background (dissolved) water color: often perceived as a "tea" color in more highly stained lakes** – The 1999 Merrymeeting Lake dissolved color concentration averaged 6.3 chloroplatinate units (cpu) and fell within the classification of a clear "no tea color" lake (Table 5). Dissolved color, or true color as it is sometimes called, is indicative of dissolved organic carbon levels in the water (a by-product of microbial decomposition). Small increases in watercolor from the natural breakdown of plant materials in and around a lake are not considered to be detrimental to water quality.

However, increased color can lower water transparency, and hence, change the public perception of water quality. The 1999 seasonal dissolved color concentration (6.3 cpu) is one of the lower values documented in Merrymeeting Lake and reflects the dry summer that limited the flushing of highly "tea" colored waters into the lake.

Table 5. Dissolved Color Classification Criteria used by the New Hampshire Lakes Lay Monitoring Program.

Range	Classification
0 - 10	Clear
10 - 20	Slightly colored
20 - 40	light tea color
40 - 80	tea colored
> 80	highly tea colored

4) Total Phosphorus: the nutrient considered most responsible for elevated microscopic plant growth in our New Hampshire Lakes. - Total phosphorus concentrations measured in the surface waters (epilimnion) were low when collected by the University of New Hampshire Freshwater Biology Group and Merrymeeting Lake volunteer monitors with a range of 3.4 to 10.8 parts per billion (ppb). With the exception of a May 6, 1999 total phosphorus concentration of 10.8 ppb, collected at Site 2 Owls Head, the 1999 total phosphorus values remained below the concentration of 10 ppb that is considered sufficient to stimulate an algal bloom.

5) Resistance against acid precipitation (measured as total alkalinity) and lake acidity (measured as pH) – The 1999 Merrymeeting Lake alkalinity measured 7.3 milligrams per liter (mg/l) which is considered typical of a lake with a moderate vulnerability to acid precipitation according to the standards devised by the New Hampshire Department of Environmental Services (Table 5). Generally speaking, the geology of the region does not contain the mineral content (e.g. limestone) which increases the buffering capacity in our surface waters. Thus, lakes in the vicinity (e.g. Lake Winnipesaukee and Wentworth Lake) have naturally low alkalinities.

Table 6. Alkalinity Classification Criteria used by the New Hampshire Department of Environmental Services

Range	Classification
< 0	Acidified
0 -2	Extremely Vulnerable
2.1 - 10.0	Moderately Vulnerable
10.1 - 25.0	Low Vulnerability
> 25.0	Not Vulnerable

The 1999 Merrymeeting Lake pH data, collected in the surface waters by the Freshwater Biology Group and the volunteer monitors ranged from 7.1 to 7.8 units and remained well within the tolerable range for most aquatic organisms.

6) Dissolved salts: measured as specific conductivity – Specific Conductivity levels documented in Merrymeeting Lake by the Freshwater Biology Group and volunteer monitors were low and ranged from 36.0 to 43.2

micro-Siemans (uS) when measured during the 1999 sampling season. High specific conductivity values can be an indication of problem areas around a lake where failing septic systems, heavy fertilizer applications and sedimentation are contributing "excessive" nutrients into the lake.

Large conductivity increases towards the lakebottom, relative to the surface waters, are often a sign of what is known as internal nutrient loading (when nutrients are released from the sediments). The 1999 Merrymeeting Lake conductivity measurements were low throughout the water column when measured by the Freshwater Biology Group on August 12 and August 31, 1999 and are not indicative of internal nutrient loading.

7) Temperature and dissolved oxygen profiles – Temperature profiles collected by the volunteer monitors indicate Merrymeeting Lake becomes stratified into three distinct thermal layers during the summer months (a warm upper water layer, **epilimnion**, overlying a layer of rapidly decreasing temperatures, **thermocline**, and a deep coldwater layer, **hypolimnion**). The formation of thermal stratification limits the replenishment of oxygen in the deeper waters and under adverse conditions can favor oxygen depletion near the lake-bottom.

Table 7. 1999 Merrymeeting Lake Dissolved Oxygen (DO) Concentrations and corresponding water quality classification criteria.

Sampling Station	DO Range (ppm) *	Classification
1 Broad Cove	3.6 - 12.9 ppm	"pristine"
2 Owls Head	6.0 - 12.8 ppm	"pristine"
3 East End	8.1 - 12.0 ppm	"pristine"

** Classification based on Dissolved oxygen Concentrations in the bottom waters (hypolimnion). Dissolved oxygen concentrations > 5 ppm are often considered typical of a "pristine" lake while dissolved oxygen concentrations < 2.0 ppm are considered typical of an "enriched" lake. Dissolved oxygen concentrations between 2.0 and 5.0 ppm are considered typical of a moderately productive "transitional" lake.*

Dissolved oxygen concentrations required for a healthy fishery – Dissolved oxygen concentrations documented by the Freshwater Biology Group (August 12 and August 31, 1999) remained high at Sites 2 Owls Head and 3 East End (Figures 25 and 26). Dissolved oxygen concentrations in the aforementioned sites remained above the concentration of 5 milligrams per liter, which is considered the minimum oxygen concentration required for the successful growth and reproduction of most coldwater fish including trout and salmon. Dissolved oxygen concentrations measured at Site 1 Broad Cove remained above 5 milligrams per liter in all but the bottom three meters of the lake and were otherwise sufficient to support a trout and salmon population (Figure 24).

Generally speaking, the 1999 dissolved oxygen concentrations were within the optimal range for the Merrymeeting Lake fishery at each of the three deep sampling stations.

8) Comparisons between the Freshwater Biology Group and lay monitor data indicate the volunteer monitors are doing an excellent job of collecting water quality data in Merrymeeting Lake.

9) Based on the current and historical water quality data, Merrymeeting Lake would be considered an unproductive "pristine" lake. A first step towards preserving high water quality in Merrymeeting Lake is to take action at the local level and do your part to minimize the number of pollutants (particularly sediment and the nutrient phosphorus) entering the lake. Whenever possible, **maintain riparian buffers** (vegetative buffers adjacent to the water body). These buffers will biologically "take up" nutrients before they enter the lake and will also provide physical filters which allow materials to settle out before reaching the lake. **Reduce fertilizer applications.** Most residents apply far more fertilizers than necessary which can be a costly expense to the homeowner and can also be detrimental to the lake as the same nutrients that make our lawns green will also stimulate plant growth in our lakes. **Make sure your septic system is well maintained** having it pumped out on a regular basis. An improperly functioning septic system can contribute "excessive" nutrients into the lake and result in early failure, costing thousands of dollars to repair or replace. Future volunteer monitoring efforts should be directed at pinpointing problematic regions around the lake where corrective and educational efforts should be focused. It is important to make sure the watershed residents are well-educated on water quality related issues. Numerous publications are available through University of New Hampshire Cooperative Extension, the New Hampshire Lakes Association, the New Hampshire Department of Environmental Services as well as several other local, state and federal agencies. It is imperative that future activities within the Merrymeeting Lake watershed are carefully thought out before implementation if water quality degradation is to be minimized. *Refer to the "Comments and Recommendations" section for more detailed suggestions.*

COMMENTS AND RECOMMENDATIONS

1) We recommend that each participating association, including the Merrymeeting Lake Association, continue to develop its database on lake water quality through continuation of the long-term monitoring program. The database currently provides information on the short-term and long-term cyclic variability that occurs in the lake and through continued monitoring will enable more reliable predictions of both short-term and long-term water quality trends.

2) We recommend initiating lake sampling early in the season (April/May) to document the lake's reaction to the nutrient and acid loadings that typically occur during and after spring thaw. Sampling should include alkalinity, chlorophyll *a*, dissolved color and Secchi Disk transparency measurements. Phosphorus samples are also recommended from both the in-lake and the tributary sampling sites. When tributary samples are collected, streamflow measurements should be included whenever possible.

3) Frequent "weekly" water quality samples, necessary to assess the current condition of Merrymeeting Lake, should continue to be collected whenever possible. It is imperative that the watershed residents are well-educated on water quality related issues if future problems are to be averted. Numerous publications are available through University of New Hampshire Cooperative Extension, the New Hampshire Lakes Association, the New Hampshire Department of Environmental Services as well as numerous other local, state and federal agencies. Refer to the section "Understanding Lake Aging (Eutrophication)" for a brief listing of some of the more useful water quality references available.

4) Changing land use within the Merrymeeting Lake watershed, the surrounding land that drains into Merrymeeting Lake, can accelerate the natural aging process (what is known as eutrophication). A typical lake fills in and becomes more productive (i.e. greener) on a geological time frame (thousands of years). However, this process can be accelerated and occur in tens of years when development, agriculture and other landscape changes occur that do not incorporate best management practices (i.e. maintaining vegetative buffer strips along the shoreline, minimizing fertilizer and pesticide applications, installing proper erosion control structures, etc.) that are set up to minimize water quality impacts. We invite interested persons to take part

in a new assessment manual, produced jointly by the **NH LLMP** and the U S Natural Resource Conservation Service **(US NRCS)**, which provides the lay-person with a systematic method for recognizing and evaluating erosion, sedimentation and related non-point source (NPS) pollutant problems in New Hampshire watersheds. Contact *Jeff Schloss (862-3848)* for further information.

TABLE OF CONTENTS

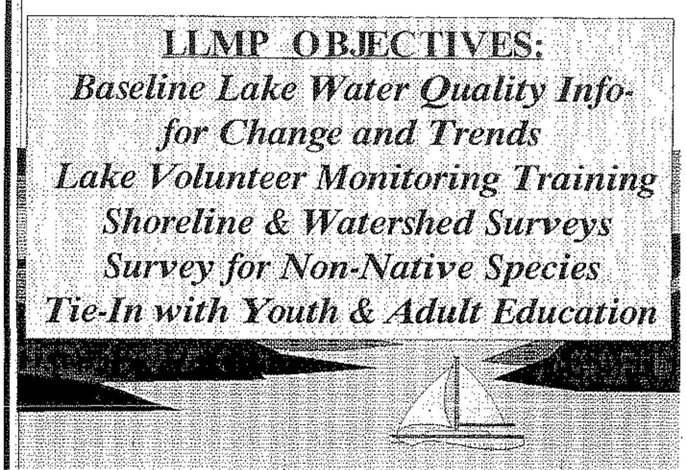
REPORT FIGURES

INTRODUCTION

The New Hampshire Lakes Lay Monitoring Program

1999 marked the twenty-first anniversary for the **NH Lakes Lay Monitoring Program (LLMP).** The **LLMP** has grown from a university class project on Chocorua Lake and pilot study on the Squam Lakes to a comprehensive state-wide program with over 500 volunteer monitors and more than 100 lakes participating. Originally developed to establish a data-base for determining long-term trends of lake water quality for science and management, the program has expanded by taking advantage of the many resources that citizen monitors can provide (Figure 1).

Figure 1. LLMP Objectives



The **NH LLMP** has gained an international reputation as a successful cooperative monitoring, education and research program. Current projects include: the use of volunteer generated data for non-point pollution studies using high tech analysis system (Geographic Information Systems and Satellite Remote Sensing), intensive watershed monitoring for the development of watershed nutrient budgets, and investigations of water quality and indicator organisms (food web analysis, fish condition, and stream invertebrates). The key ingredients responsible for the success of the program include innovative costshare funding and cost reduction, assurance of credible data, practical sampling protocols and, most importantly, the interest and motivation of our volunteer monitors.

Figure 2. Awards & Recognition

The 1999 sampling season was another exciting year for the **New Hampshire Lakes Lay Monitoring Program**. National recognition for the high quality of work by you, the volunteer monitors, continued with awards, requests for program information and invitations to speak at national conferences (Figure 2).

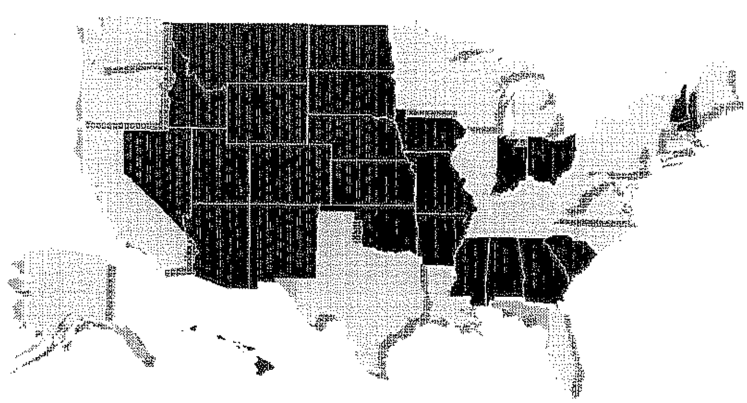
Watersheds and water resources were important topics covered in a Community Mapping with GIS course that was held in Durham at the end of June. This course for educators, community leaders and other interested persons taught participants how to use the desktop Geographic Information System software - a computer based technology that allows users to create, map, manage, analyze and manipulate data and related locational information. The UNH Cooperative Extension Lakes Lay Monitoring Program was a co-sponsor of a week long workshop: "Working at a Watershed Level" part of the Environmental Protection Agency's Watershed Academy. Seventy five participants from as far away as Panama and Texas learned the latest techniques to perform watershed assessments from national experts. The workshop included field trips around the Oyster River Watershed to construction sites, logging sites, dairy farms and parking lots to assess potential pollution situations and evaluate practices put in place to prevent deleterious impacts.

Research initiated this summer by the New Hampshire Lakes Lay Monitoring Program and collaborators Dr. John Sasner and Dr. Jim Haney of the UNH Center for Freshwater Biology was focused on how watershed development and our activities on the landscape play a role in creating potentially toxic algae blooms. Analogous to the 'red tide" of estuaries, certain blue-green algae (microscopic bacteria) can produce toxins that are heath risks to animals and humans. A $150,000 grant from the Environmental Protection Agency and additional assistance from the University's Water Resources Research Center has supported field trips to over 50 lakes throughout the state to monitor these populations, test for toxicity, trace the movement of toxins into mussels, crayfish and fish and determine what conditions favor toxic blooms of these organisms. Lakes Lay Monitoring Program participants have helped make this EPA funded project a success by providing in-lake transportation and our participants will continue to assist University of New Hampshire researches in the year 2000 by collecting accessory data for this project.

As in previous years, watershed assessment by volunteer monitors in the Lakes Lay Monitoring Program (LLMP) continued throughout the summer. Analysis of results from a LLMP watershed nutrient and water budget of Lake Chocorua in Tamworth has lead to a project funded and facilitated by the NH Department of Transportation,

Figure 3. National LLMP Support to Volunteer Monitoring Programs

NH LLMP Directly inolved with the Initiation, Expansion or Support of Volunteer Programs in 24 States.



Light gray shading denotes LLMP assisted states the Natural Resources Conservation Service, North Country Resource and Development and the NH Department of Environmental Services to correct runoff, erosion and drainage problems along Route 16. We continue to be listed as a model citizen monitoring program on the Environmental Success Index of Renew America, the Environmental Network Clearinghouse and the National Awards Council for Environmental Sustainability. To date, the approach and methods of the **NH LLMP** have been adopted by new or existing programs in twenty four states and eleven countries (Figure 3)!

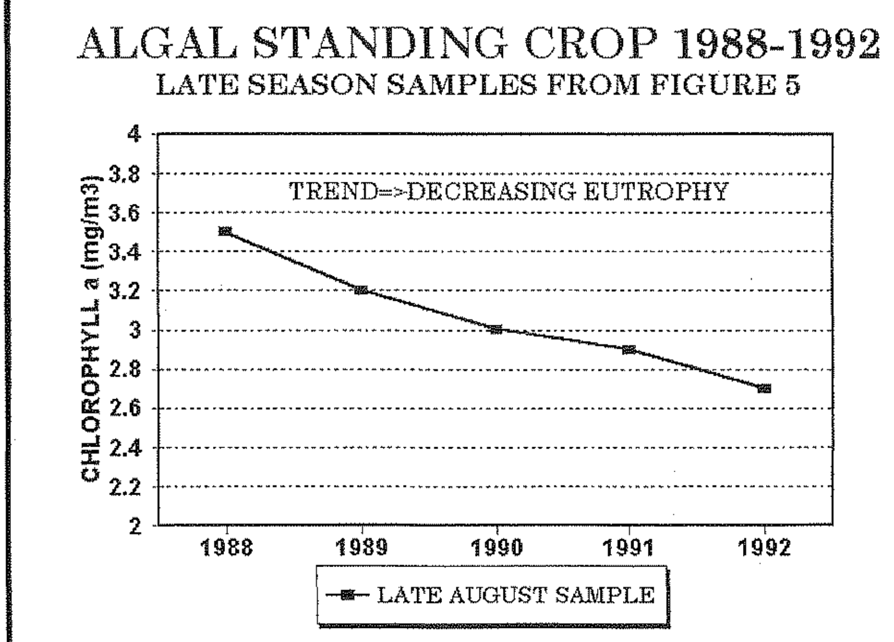
Importance of Long-term Monitoring

A major goal of our monitoring program is to identify any short or long-term changes in the water quality of the lake. Of major concern is the detection of cultural eutrophication: increases in the productivity of the lake, the amount of algae and plant growth, due to the addition of nutrients from human activities. Changes in the natural buffering capacity of the lakes in the program is also a topic of great concern, as New Hampshire receives large amounts of acid precipitation, yet most of our lakes contain little mineral content to neutralize this type of pollution.

For almost two decades, weekly data collected from lakes participating in the **New Hampshire Lakes Lay Monitoring Program** have indicated there is quite a variation in water quality indicators through the open water season (April through November) on the majority of lakes. Short-term differences may be due to variations in weather, lake use, or other chance events. Monthly sampling of a lake during a single summer provides some useful information, but there is a greater chance that important short-term events such as algal blooms or the lake's response to storm run-off will be missed. These short-term fluctuations may be unrelated to the actual long-term trend of a lake or they may be indicative of the changing status or "health" of a lake.

Consider the hypothetical data depicted in Figure 4. Sampling only once a year during August from 1988 to 1992 produced a plot suggesting a decrease in eutrophication. However, the actual long-term term trend of the lake, increasing eutrophy, can only be clearly discerned by frequent sampling over a ten year period (Figure 5). In this instance, the information

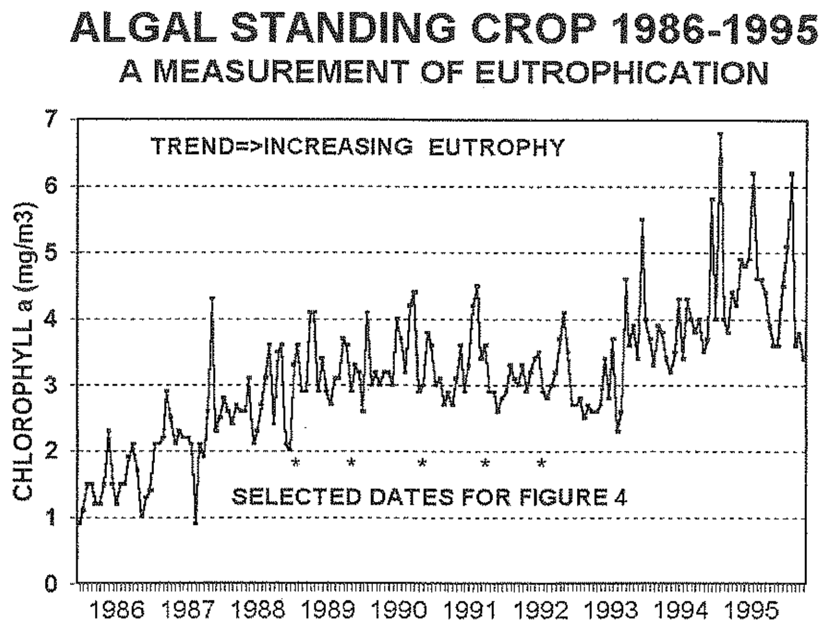
Figure 4.



necessary to distinguish between short-term fluctuations "noise" and long-term trends "signal" could only be accomplished through the frequent collection of water quality data over many years. To that end, the establishment of a long term database was essential to trend detection.

The number of seasons it takes to distinguish between the noise and the signal is not the same for each lake. Evaluation and interpretation of a long-term data base will indicate that the water quality of the lake has worsened, improved, or remained the same. In addition, different areas of a lake may show a different response. As more data are collected, prediction of current and future trends can be made. No matter what the outcome, this information is essential for the intelligent management of your lake.

Figure 5



There are also short-term uses for lay monitoring data. The examination of different stations in a lake can disclose the location of specific problems and corrective action can be initiated to handle the situation before it becomes more serious. On a lighter note, some associations post their weekly data for use in determining the best depths for finding fish!

It takes a considerable amount of effort as well as a deep concern for one's lake to be a volunteer in the **NH Lakes Lay Monitoring Program**. Many times a monitor has to brave inclement weather or heavy boat traffic to collect samples. Sometimes it even may seem that one week's data is just the same as the next week's data. Yet every sampling provides important information on the variability of the lake.

We are pleased with the interest and commitment of our Lay Monitors and are proud that their work is what makes the **NH LLMP** the most extensive, and we believe, the best volunteer program of its kind.

Purpose and Scope of This Study

1999 was the sixteenth year that water quality monitoring was undertaken by the **Freshwater Biology Group** in conjunction with the Merrymeeting Lake Association. The monitoring program was designed to continue adding data to the long-term data base established. Sampling emphasis was placed on three open water deep sampling stations (Sites 1 Broad Cove, 2 Owls Head and 3 East End) while additional water quality data were historically collected at selected tributary sampling stations around the lake (Figure 9).

The primary purpose of this report is to discuss results of the 1999 monitoring season with emphasis on current conditions of Merrymeeting Lake including the extent of eutrophication and the lake's susceptibility to increasing acid precipitation. This information is part of a large data base of historical and more recent data compiled and entered onto computer files for New Hampshire lakes that include New Hampshire Fish and Game surveys of the 1930's, the surveys conducted by the New Hampshire Water Supply and Pollution Control Commission and the **FBG** surveys. However, care must be taken when comparing current results with early studies. Many complications arise due to methodological differences of the various analytical facilities and technological improvements in testing.

Climatic Summary - 1999

Water Quality and the Weather

Since the start of **the New Hampshire Lakes Lay Monitoring Program (NH LLMP)**, questions have been asked pertaining to water quality changes that occur in our New Hampshire lakes and ponds. The most commonly noticed changes are those associated with decreasing water clarities, increasing algal growth (greenness), and increasing plant growth around the lake's periphery. Over the long haul, changes such as these are attributed to a lake's natural aging process; what is known as **"eutrophication"**. However, short-term water quality changes such as those mentioned above are often encountered even in our most pristine lakes and ponds and often coincide with variations in weather variables such as precipitation and temperature.

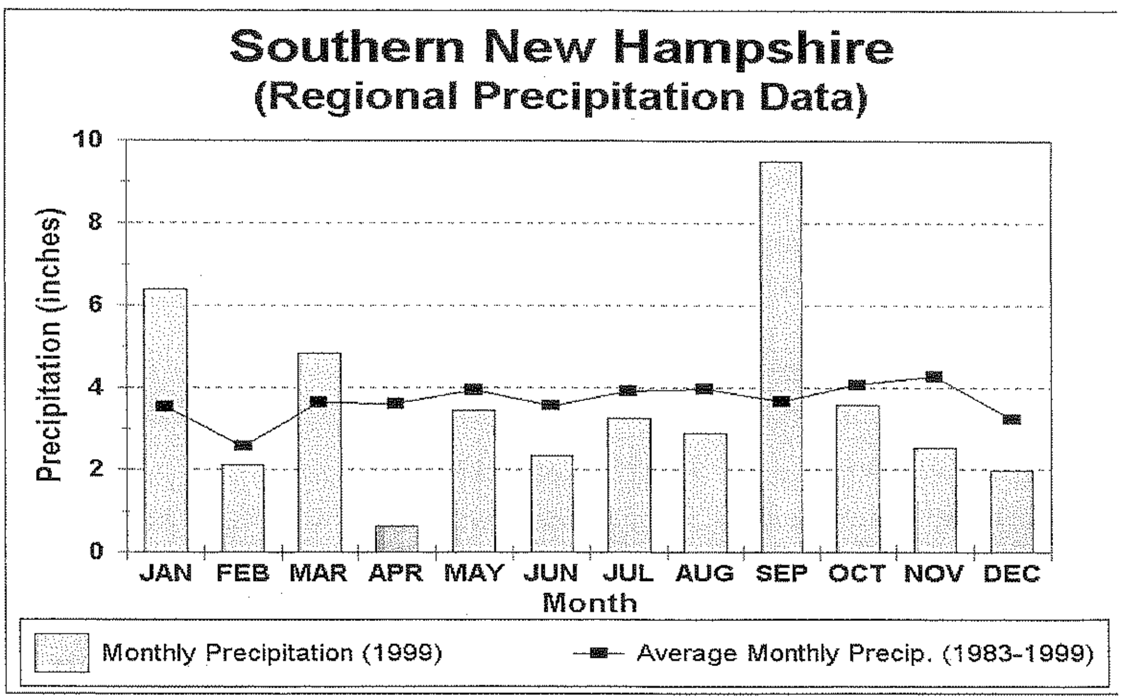
These climate swings can have a profound effect on water quality, sometimes positive and other times negative. For instance, 1996 was a wet year, relative to other years of **LLMP** water quality monitoring. This translated into reduced water clarities, elevated microscopic plant "algal" growth and increased total phosphorus concentrations for most participating **LLMP** lakes. Past monitoring through the **NH LLMP** has recognized that wet years such as 1996 often result in poorer water in many of our New Hampshire lakes, relative to years with more typical precipitation levels. "Excessive" runoff associated with wet periods often facilitates the transport of pollutants into the water body such as nutrients (including phosphorus), sediment, dissolved colored compounds, as well as toxic materials such as herbicides, automotive oils, etc. As a result, lakes often respond with shallower (less clear) water clarities and elevated "algal" abundance during these periods. Similarly, short term storm events can have a profound effect on the water quality. Take for instance the "100 year storm" (October 21-22, 1996) that blanketed southern New Hampshire with approximately 6 inches of rain over a 30 hour period. This storm resulted in increased sedimentation and organic matter loading into our lakes as material was flushed into the water bodies from the adjacent landscape. Likewise, the heavy rains that saturated the soil and resulted in flood conditions in June 1998 (heaviest rains occurring on June 12 and 13) resulted in significantly shallower Secchi Disk transparency readings in the weeks to months that followed. While events such as October 1996 and June 1998 storms are short lived, they can have a profound effect on our water quality in the weeks to months that follow, particularly when nutrients that stimulate plant growth are retained in the lake.

NH LLMP data collected during dry years such as 1985 can have the opposite effect, reducing the transport of pollutants into the lake and in turn resulting in higher water quality measured as deeper water transparencies, lower microscopic plant "algae" concentrations and lower nutrient concentrations. Do all lakes experience poorer water quality as a result of heavy precipitation events? Simply stated, the answer is no. While most New Hampshire lakes are characterized by reduced water clarities, increased nutrients and elevated plant "algal" concentrations following periods, or years, of heavy precipitation, a handful of lakes actually benefit from these types of events (heavy precipitation). These are generally lakes characterized by high nutrient concentrations and high "algal" concentrations that are diluted by watershed runoff and thus benefit during years, or periods, of heavy rainfall. However, such lakes may be susceptible to nutrients entering the lake from seepage sources such as poorly functioning septic systems.

Precipitation (1999)

New Hampshire was off to a wet start during the first quarter of 1998 with precipitation levels well above average during the months of January and March relative to the seventeen year average from 1983 through 1999 (Figure 6). However, the precipitation patterns abruptly changed during the month of April when the rainfall was the least recorded between 1983 and 1999. Precipitatation levels in subsequent months were also below average, through the month of August, and culminated in drought conditions during much of the summer. Over nine inches of rain fell during the month of September, well above the average precipitation documented between 1983 and 1999, and helped alleviate the drought conditions. Precipitation levels were again below average between October and December to round out the calander year. Interestingly, the 1999 seasonal precipitation level for southern New Hampshire (43.53 inches) is only slightly below the average yearly precipitation level of 43.53 inches documented over the past seventeen years (1983-1999). However, the timing of the precipitation/lack of precipitation did have a significant impact on water quality documented in our New Hampshire lakes.

Figure 6.



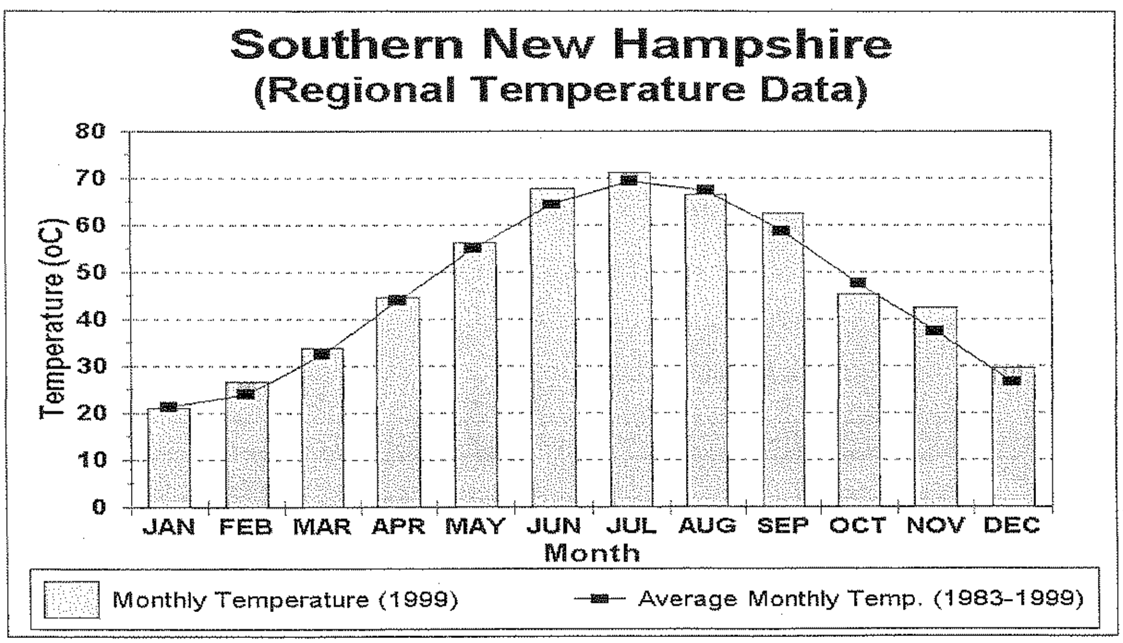
Temperature (1999)

Similar to the impact of precipitation extremes, temperature extremes can have far reaching effects on the water quality, particularly early in the year and during the summer months. Atypically warm spells can account for a rapid snow-pack melt resulting in flooding and a massive influx of materials (e.g. nutrients, sediments) into our lakes during the late winter and early spring months. These early spring runoff periods also coincide with minimal vegetative cover (that acts as a pollutant filter and soil stabilizer) and thus leaves the landscape highly susceptible to erosional forces. As we progress into the summer months, atypically warm periods can enhance both microscopic "algal" and macroscopic "aquatic weed" plant growth. During the summer months (the summer growing season) above average temperatures often result in algal blooms that under optimal conditions can reach nuisance proportions. These can include surface algal "scums" that cover the lake and wash up on the shore in response to the prevailing winds.

During years such as 1994 and 1995, when above average temperatures characterized the summer months, participating **NH LLMP** lakes were generally characterized by increased algal concentrations, particularly in the shallows, where filamentous cotton candy like clouds of algae flourished. Other **NH LLMP** lakes had increased algal growth "greenness" and shallower water transparencies during these "hot" periods.

The 1999 monthly temperatures were generally at, or above, the seventeen year average (1983-1999) with the exception of the month of October during which the average monthly temperatures were approximately two degrees Fahrenheight below the seventeen year average (Figure 7). Near-average to above-average tem-

Figure 7.



peratures through the month of April translated into a limited snowpack accumulation and sporadic periods of spring snowmelt. The lack of significant snowpack accumulation helped minimize erosional problems associated with the typically heavy period of spring runoff during the months of March and April.

The above average temperatures encountered during the summer months were conducive to algal growth and did stimulate nuisance algal blooms in some of our New Hampshire lake. Lakes experiencing summer algal blooms were most often those that were naturally characterized by moderate to high nutrient concentrations (i.e. phosphorus). Most Participating **NH LLMP** lakes are characterized by relatively low phosphorus concentrations and thus were not generally plagued with summer algal blooms.

Water Quality Impacts

Water Transparency and Dissolved "tea" Colored Water

As previously indicated, shallower water transparency readings are characteristic of most New Hampshire lakes during wet years and following short term precipitation events. Wet periods often coincide with greater concentrations of dissolved "tea" colored compounds (dissolved organic matter resulting from the breakdown of vegetation and soils) washed in from surrounding forests and wetlands. Dissolved water color is not indicative of water quality problems (although large increases in dissolved color sometimes follow large land clearing operations) but in some of our more pristine program lakes, it nevertheless has a large effect on water clarity changes. Data collected by the **Freshwater Biology Group** since 1985 indicate most lakes are characterized by higher dissolved "tea" colored water during wet years relative to years more typical in terms of annual precipitation levels. In some of our more highly "tea" colored lakes the early spring months are also characterized by higher dissolved color concentrations, relative to mid-summer levels, due to the heavy runoff periods that flush highly colored water into our lakes during the period of spring snowmelt and following heavy spring rains.

Sediment Loading

Sediments are continuously flushed into our lakes and ponds during periods of heavy watershed runoff, particularly early in the season and again during and following sporadic storm events during the summer and fall months. Many New Hampshire lakes experience water clarity decreases following storm events such as those described above. Lakes, ponds and rivers are particularly susceptible to sediment loadings in the early spring months when vegetated shoreside buffers, often referred to as riparian buffers, are reduced. With limited vegetation to trap sediments and suspended materials, a high percentage of the particulate debris and dissolved materials are flushed into the lake. Other activities such as logging, agriculture, construction and land clearing activities can also increase sediment displacement during and following heavy storm events throughout the year and are the likely culprits of excessive sediment loading in many of our lakes and ponds. As these materials (sediments) are transported into surface waters they can degrade water quality in a number of ways. When fine sediments (silt) enter a lake they tend to remain in the water column for relatively long periods of time. These suspended sediments can be abrasive to fish gills, ultimately leading to fish kills. Suspended sediments also reduce the available light necessary for plant growth that can result in plant die-offs and a subsequent oxygen depletion under extreme conditions.

As sediments settle out of the water column they can smother bottom dwelling aquatic organisms and smother fish spawning habitat. As the dead materials begin to decay the result could be noxious odors as well as stimulation of nuisance plant growth (i.e. scums along the lakebottom; new macroscopic plant growth). Note: one should keep in mind that nuisance plants such as water milfoil (*Myriophyllum heterophyllum*) will generally regenerate more rapidly than more favorable plant forms. This can result in more problematic weed beds than those present before the disturbance. Habitat changes associated with the accumulation of fine sediments and associated "muck" might also favor increased nuisance plant growth in the future. Another un-favorable attribute of sediment loading is that the sediments tend to carry with them other sorts of contaminant such as pathogens, nutrients and toxic chemicals (i.e. herbicides and pesticides).

Early symptoms of excessive sediment runoff include deposits of fine material along the lakebottom, particularly in close proximity to tributary inlets and disturbed regions previously discussed (i.e. construction sites, logging sites, etc.). Silt may be visible covering rocks or aquatic vegetation along the lakebottom. During periods of heavy overland runoff the water might appear brown and turbid which reflects the sediment load. As material collects along the lakebottom you might notice a change in the weed composition reflecting a change in the substrate type (note: aquatic plants will display natural changes in abundance and distribution, so be careful not to jump to hasty conclusions). If excessive sediment loading is suspected, take a closer look in these areas and assess whether or not the change is associated with sediment loading (look for the warning signs discussed above) or whether the changes might be attributable to other factors.

Nutrient Loading

Nutrient loading is often greatest during heavy precipitation events, particularly during the periods of heavy watershed runoff. Phosphorus is generally considered the limiting nutrient for excessive plant and algal growth in New Hampshire lakes. Elevated phosphorus concentrations are generally most visible when documented in our tributary inlets where nutrients are concentrated in a relatively small volume of water. Much of the phosphorus entering our lakes is attached to particulate matter (i.e. sediments, vegetative debris), but may also include dissolved phosphorus associated with fertilizer applications and septic system discharge.

Microscopic "Algal" and Macroscopic "Weed" Plant Growth

Historical **Lakes Lay Monitoring Program** data indicate most lake experience "algal blooms" during years with above average summer temperatures (June, July and August) while years with heavy precipitation are also associated with an increased frequency and occurrence of "algal blooms" among participating **LLMP** lakes. Algal blooms are often green water events associated with decreases in water clarity due to their ability to absorb and scatter light within the water column, but can also accumulate near the lake bottom in shallow areas as "mats" or on the water surface as "scums" and "clouds". Some years, such as 1996, the algal blooms are predominantly green water events composed of algae distributed within the water column. New Hampshire lakes were particularly susceptible to algal blooms in 1996 as a function of the heavy runoff associated with the atypically wet year. Wet years such as 1996 can be particularly hard on lakes where excessive fertilizer applications, agricultural practices, construction activities, etc. favor the displacement of nutrients into surface waters. The occasional formation of certain algal blooms is a naturally occurring phenomenon and is not necessarily associated with changes in lake productivity. However, increases in the occurrence of bloom conditions can be a sign of eutrophication (the "greening" of a lake). Shifts from benign (clean water) forms to nuisance (polluted water) cyanobacterial forms such as *Anabaena*, *Aphanizomenon* and *Oscillatoria*, can also be a warning sign that improper land use practices are contributing excessive nutrients into the lake.

Filamentous cotton-candy like "clouds" of the nuisance green filamentous algae, *Mougeotia*, and related species have been well documented in 1994 and 1995 when the temperatures during the months of June and July were well above normal. These algal "clouds" often develop within nearshore weed beds where they can be seen along the lakebottom and tend to flourish during warm periods. During cooler years, this type of algal growth is kept in "check" and generally does not reach nuisance proportions.

In other lakes, metalimnetic algae, algae which tend to grow in a thin layer along the thermocline gradient in a lake's middle depths, sometimes migrate up towards the lake surface causing a "bloom" event. If these algae are predominantly "nuisance" forms, like certain green or blue-green algae, they can be an early indication of nutrient loading.

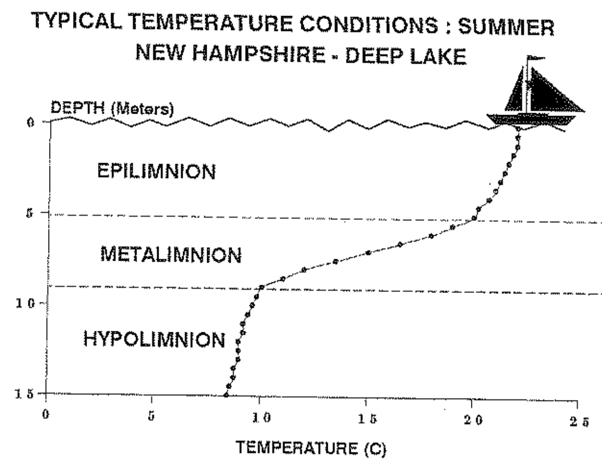
DISCUSSION OF LAKE AND STREAM MONITORING MEASUREMENTS

The section below details the important concepts involved for the various testing procedures used in the **New Hampshire Lakes Lay Monitoring Program**. Certain tests or sampling performed at the time of the optional **Freshwater Biology Group** field trip are indicated by an asterisk (*).

Thermal Stratification in the Deep Water Sites

Lakes in New Hampshire display distinct patterns of temperature stratification, that develop as the summer months progress, where a layer of warmer water (the **epilimnion**) overlies a deeper layer of cold water (**hypolimnion**). The layer that separates the two regions characterized by a sharp drop in temperature with depth is called the **thermocline** or **metalimnion** (Figure 8). Some shallow lakes may be continually mixed by wind action and will never stratify. Other lakes may only contain a developed epilimnion and metalimnion.

Figure 8



Water Transparency

Secchi Disk depth is a measure of the water transparency. The deeper the depth of Secchi Disk disappearance, the more transparent the lake water; light penetrates deeper if there is little dissolved and/or particulate matter (which includes both living and non-living particles) to absorb and scatter it.

In the shallow areas of many lakes, the Secchi Disk will hit bottom before it is able to disappear from view (what is referred to as a "Bottom Out" condition). Thus, Secchi Disk measurements are generally taken over the deepest sites of a lake. Transparency values greater than 4 meters are typical of clear, unproductive lakes while transparency values less than 2.5 meters are generally an indication of highly productive lakes. Water transparency values between 2.5 meters and 4 meters are generally considered indicative of moderately productive lakes.

Chlorophyll *a*

The chlorophyll *a* concentration is a measurement of the standing crop of phytoplankton and is often used to classify lakes into categories of productivity called trophic states. **Eutrophic** lakes are highly productive with large concentrations of algae and aquatic plants due to nutrient enrichment. Characteristics include accumulated organic matter in the lake basin and lower dissolved oxygen in the bottom waters. Summer chlorophyll *a* concentrations average above 7 mg m^3 (7 milligrams per cubic meter; 7 parts per billion). **Oligotrophic** lakes have low productivity and low nutrient levels and average summer chlorophyll *a* concentrations that are generally less than 3 mg m^3. These lakes generally have cleaner bottoms and high dissolved oxygen levels throughout. **Mesotrophic** lakes are intermediate in productivity with concentrations of chlorophyll *a* generally between 3 mg m^3 and 7 mg m^3. Testing is sometimes done to check for **metalimnetic algal populations**, algae that layer out at the thermocline and generally go undetected if only epilimnetic (point or integrated) sampling is undertaken. Chlorophyll concentrations of a water sample collected in the thermocline is compared to the integrated epilimnetic sample. Greater chlorophyll levels of the point sample, in conjunction with microscopic examination of the samples (see Phytoplankton section below), confirm the presence of such a population of algae. These populations should be monitored as they may be an indication of increased nutrient loading into the lake.

Turbidity *

Turbidity is a measure of suspended material in the water column such as sediments and planktonic organisms. The greater the turbidity of a given water body the lower the Secchi Disk transparency and the greater the amount of particulate matter present. Turbidity is measured as nephelometric turbidity units (NTU), a standardized method among researchers. Turbidity levels are generally low in New Hampshire reflecting the pristine condition of the majority of our lakes and ponds. Increasing turbidity values can be an indication of increasing lake productivity or can reflect improper land use practices within the watershed which destabilize the surrounding landscape and allow sediment flushing into the lake.

While Secchi Disk measurements will integrate the clarity of the water column from the surface waters down to the depth of disappearance, turbidity measurements are collected at discrete depths from the surface down to the lakebottom. Such discrete sampling can identify layering algal populations (previously discussed) that are undetectable when measuring Secchi Disk transparency alone.

Dissolved Color

The dissolved color of lakes is generally due to dissolved organic matter from **humic substances**, which are naturally-occurring polyphenolic compounds leached from decayed vegetation. Highly colored or "stained" lakes have a "tea" color. Such substances generally do not threaten water quality except as they diminish sunlight penetration into deep waters. Increases in dissolved watercolor can be an indication of increased development within the watershed as many land clearing activities (construction, deforestation, and the resulting increased run-off) add additional organic material to lakes. Natural fluctuations of dissolved color occur when storm events increase drainage from wetlands areas within the watershed. As suspended sediment is a difficult and expensive test to undertake, both dissolved color and chlorophyll information are important when interpreting the Secchi Disk transparency

Dissolved color is measured on a comparative scale that uses standard chloroplatinate dyes and is designated as a color unit or ptu. Lakes with color below 10 ptu are very clear, 10 to 20 ptu are slightly colored, 20 to 40 ptu are lightly tea colored, 40 to 80 ptu are tea colored and greater than 80 ptu indicates highly colored waters. Generally the majority of New Hampshire lakes have color between 20 to 30 ptu.

Total Phosphorus

Of the two "nutrients" most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth, and therefore the more important to monitor and control. Phosphorus is generally present in lower concentrations, and its sources arise primarily through human related activity in a watershed. Nitrogen can be fixed from the atmosphere by many bloom-forming blue-green bacteria, and thus it is difficult to control. The total phosphorus includes all dissolved phosphorus as well as phosphorus contained in or adhered to suspended particulates such as sediment and plankton. As little as 10 parts per billion of phosphorus in a lake can cause an algal bloom.

Generally, in the more pristine lakes, phosphorus values are higher after spring melt when the lake receives the majority of runoff from its surrounding watershed. The nutrient is used by the algae and plants which in turn die and sink to the lake bottom causing surface water phosphorus concentrations to decrease as the summer progresses. Lakes with nutrient loading from human activities and sources (Agriculture, Logging, Sediment Erosion, Septic Systems, etc.) will show greater concentrations of nutrients as the summer progresses or after major storm events.

Streamflow

Streamflow, when collected in conjunction with depth contour information, is a measure of the volume of water traversing a given stream stretch over a period of time and is often expressed as cubic meters per second. Knowledge of the streamflow is important when determining the amount of nutrients and other pollutants that enter a lake. Knowledge of the streamflow in conjunction with nutrient concentrations, for instance, will provide the information necessary to calculate phosphorus loading values and will in turn be useful in discerning the more impacted areas within a watershed.

pH *

The pH is a way of expressing the acidic level of lake water, and is generally measured with an electrical probe sensitive to hydrogen ion activity. The pH scale has a range of 1 (very acidic) to 14 (very "basic" or alkaline) and is logarithmic (i.e.: changes in 1 pH unit reflect a ten times difference in hydrogen ion concentration). Most aquatic organisms tolerate a limited range of pH and most fish species require a pH of 5.5 or higher for successful growth and reproduction.

Alkalinity

Alkalinity is a measure of the buffering capacity of the lake water. The higher the value the more acid that can be neutralized. Typically lakes in New Hampshire have low alkalinities due to the absence of carbonates and other natural buffering minerals in the bedrock and soils of lake watersheds.

Decreasing alkalinity over a period of a few years can have serious effects on the lake ecosystem. In a study on an experimental acidified lake in Canada by Schindler, gradual lowering of the pH from 6.8 to 5.0 in an 8-year period resulted in the disappearance of some aquatic species, an increase in nuisance species of algae and a decline in the condition and reproduction rate of fish. During the first year of Schindler's study the pH remained unchanged while the alkalinity declined to 20 percent of the pre-treatment value. The decline in alkalinity was sufficient to trigger the disappearance of zooplankton species, which in turn caused a decline in the "condition" of fish species that fed on the zooplankton.

The analysis of alkalinity employed by the **Freshwater Biology Group** includes use of a dilute titrant allowing an order of magnitude greater sensitivity and precision than the standard method. Two endpoints are recorded during each analysis. The first endpoint (gray color of dye; pH endpoint of 5.1) approximates low level alkalinity values, while the second endpoint (pink dye color; pH endpoint of 4.6) approximates the alkalinity values recorded historically, such as NH Fish and Game data, with the methyl-orange endpoint method.

The average alkalinity of lakes throughout New Hampshire is low, approximately 6.5 mg per liter (calcium carbonate alkalinity). When alkalinity falls below 2 mg per liter the pH of waters can greatly fluctuate. Alkalinity levels are most critical in the spring when acid loadings from snowmelt and run-off are high, and many aquatic species are in their early, and most susceptible, stages of their life cycle.

Specific Conductivity *

The specific conductance of a water sample indicates concentrations of dissolved salts. Leaking septic systems and deicing salt runoff from highways can cause high conductivity values. Fertilizers and other pollutants can also increase the conductivity of the water. Conductivity is measured in micro**mhos** (the opposite of the measurement of resistance **ohms**) per centimeter, more commonly referred to as micro-Siemans (υS).

Dissolved Oxygen and Free Carbon Dioxide *

Oxygen is an essential component for the survival of aquatic life. Submergent plants and algae take in carbon dioxide and create oxygen through **photosynthesis** by day. **Respiration** by both animals and plants uses up oxygen continually and creates **carbon dioxide**. Dissolved oxygen profiles determine the extent of declining oxygen concentrations in the lower waters. High carbon dioxide values are indicative of low oxygen conditions and accumulating organic matter. For both gases, as the temperature of the water decreases, more gas can be dissolved in the water.

The typical pattern of clear, unproductive lakes is a slight decline in hypolimnetic oxygen as the summer progresses. Oxygen in the lower waters is important for maintaining a fit, reproducing, cold water fishery. Trout and salmon generally require oxygen concentrations above 5 mg per liter (parts per million) in the cool deep waters. On the other hand, carp and catfish can survive very low oxygen conditions. Oxygen above the lake bottom is important in limiting the release of nutrients from the sediments and minimizing the collection of undecomposed organic matter.

Bacteria, fungi and other **decomposers** in the bottom waters break down organic matter originating from the watershed or generated by the lake. This process uses up oxygen and produces carbon dioxide. In lakes where organic matter accumulation is high, oxygen depletion can occur. In highly stratified eutrophic lakes the entire hypolimnion can remain unoxygenated or **anaerobic** until fall mixing occurs.

The oxygen peaks occurring at surface and mid-lake depths during the day are quite common in many lakes. These characteristic **heterograde oxygen curves** are the result of the large amounts of oxygen, the by-product of photosynthesis, collecting in regions of high algal concentrations. If the peak occurs in the thermocline of the lake, metalimnetic algal populations (discussed above) may be present.

Underwater Light *

Underwater light available to photosynthetic organisms is measured with an **underwater photometer** which is much like the light meter of a camera (only waterproofed!). The **photic zone** of a lake is the volume of water capable of supporting photosynthesis. It is generally considered to be delineated by the water's surface and the depth that light is reduced to one percent surface iridescence by the absorption and scattering properties of the lake water. The one percent depth is sometimes termed the **compensation depth**. Knowledge of light penetration is important when considering lake productivity and in studies of submerged vegetation. Discontinuity (abrupt changes in the slope) of the profiles could be due to metalimnetic layering of algae or other particulates (discussed above). The underwater photometer allows the investigator to measure light at depths below the Secchi Disk depth to supplement the water clarity information.

Indicator Bacteria *

Certain disease causing organisms, pathogenic bacteria, viruses and parasites, can be spread through contact with polluted waters. Faulty septic systems, sewer leaks, combined sewer overflows and the illegal dumping of wastes from boats can contribute fecal material containing these pathogens. Typical water testing for pathogens involves the use of detecting coliform bacteria. These bacteria are not usually considered harmful themselves but they are relatively easy to detect and can be screened for quickly. Thus, they make good surrogates for the more difficult to detect pathogens.

Total coliform includes all coliform bacteria which arise from the gut of animals or from vegetative materials. **Fecal coliform** are those specific organisms that inhabit the gut of warm blooded animals. Another indicator organism **Fecal streptococcus** (sometimes referred to as **enterococcus**) also can be monitored. The ratio of fecal coliform to fecal strep may be useful in suggesting the type of animal source responsible for the contamination. In 1991, the State of New Hampshire changed the indicator organism of preference to E. Coli which is a specific type of fecal coliform bacteria thought to be a better indicator of human contamination. The new state standard requires Class A "bathing waters" to be under 88 organisms (referred to as colony forming units; cfu) per 100 milliliters of lakewater.

Ducks and geese are often a common cause of high coliform concentrations at specific lake sites. While waterfowl are important components to the natural and aesthetic qualities of lakes that we all enjoy, it is poor management practice to encourage these birds by feeding them. The lake and surrounding area provides enough healthy and natural food for the birds and feeding them stale bread or crackers does nothing more than import additional nutrients into the lake and allows for increased plant growth. As birds also are a host to the parasite that causes "swimmers itch", waterfowl roosting areas offer a greater chance for infestation to occur. Thus while leaving offerings for our feathered friends is enticing, the results can prove to be detrimental to the lake system and to human health.

Phytoplankton *

The planktonic community includes microbial organisms that represent diverse life forms, containing photosynthetic as well as non-photosynthetic types, and including bacteria, algae, crustaceans and insect larvae (the insect larvae and zooplankton are discussed below in separate sections). Because planktonic algae or "phytoplankton" tend to undergo rapid seasonal cycles on a time scale of days and weeks, the levels of populations found should be considered to be most representative of the time of collection and not necessarily of other times during the ice-free season, especially the early spring and late fall periods.

The composition and concentration of phytoplankton can be indicative of the trophic status of a lake. Seasonal patterns do occur and must be considered. For example **diatoms**, tend to be most abundant in April-June and October-November, in the surface or epilimnetic layers of New Hampshire lakes. As the summer progresses, the dominant types might shift to **green algae** or **golden algae**. By late season **Blue-green bacteria** generally dominate. In nutrient rich lakes, nuisance green algae and/or bluegreen bacteria might dominate continually. After fall mixing diatoms might again be found to bloom.

Zooplankton *

There are three groups of zooplankton that are generally prevalent in lakes: the **protozoa**, **rotifers** and **crustaceans**. Most research has been devoted to the last two groups although protozoa may be found in substantial amounts. Of the rotifers and the crustaceans, time and budgetary constraints usually make it necessary to sample only the larger zooplankton (macrozooplankton; larger than 80 or 150 microns; 1 million microns make up a meter). Thus, zooplankton analysis is generally restricted only to the larger crustaceans. Crustacean zooplankton are very sensitive to pollutants and are commonly used to indicate the presence of toxic substances in water. The crustaceans can be divided into two groups, the **cladocerans** (which include the "water fleas") and the **copepods**.

Macrozooplankton are an important component in the lake system. The filter feeding of the herbivorous ("grazing") species may control the population size of selected species of phytoplankton. The larger zooplankton can be an important food source for juvenile and adult planktivorous fish. All zooplankton play a part in the recycling of nutrients within the lake. Like the phytoplankton, zooplankton, tend to undergo rapid seasonal cycles. Thus, the zooplankton population density and diversity should be considered to be most representative of the time of collection and not necessarily of other times during the ice-free season, especially the early spring and late fall periods.

Macroinvertebrates *

Macroinvertebrates generally refer to the aquatic insect community living near the bottom substrate (i.e. sediments) while other invertebrate groups such as the crayfish, leeches and the aquatic worms are also included. Like the phytoplankton and zooplankton, previously discussed, the macroinvertebrates undergo seasonal cycles and are most representative of conditions for particular periods of the year. The mayflies are probably the most well known example of a seasonal aquatic macroinvertebrate as mayfly populations metamorphosize into adults as the water temperatures increase in the spring and thus giving rise to the name "mayflies". Macroinvertebrates are also sensitive to environmental conditions such as streamflow, temperature and food availability and are most representative of particular habitats along the stream continuum (i.e. some organisms prefer slower moving stream reaches while others prefer rapidly flowing waters).

Macroinvertebrates are an essential component to a healthy aquatic habitat. Macroinvertebrates help decompose organic matter entering the system such as leaves and twigs and also serve as a food source for many fish species.

While some macroinvertebrates are capable of breathing air as we do, others have gills and utilize oxygen dissolved in the water much as fish do. Macroinvertebrates also vary in their tolerance to depleting dissolved oxygen concentrations making them a good indicator of pollutants coming into the water body. The caddisflies (Trichop-tera), the mayflies (Ephemeroptera) and the stoneflies (Plecoptera) are often considered highly sensitive to pollution while the "true" flies (Diptera) are often considered highly tolerant to pollution. However, exceptions to the above categorizations are often encountered.

A variety of indices have been proposed to characterize water bodies over a gradient of pollution levels ranging from least polluted to most polluted scenarios and often designated by assigning a numerical delineator (i.e. 1 is least polluted while 10 is most polluted). Such an index, the Hilsenhoff Biotic Index (HBI), or a modification thereof, is commonly used by stream monitoring programs around the country. Macroinvertebrate data are useful in discerning the more impacted areas within the watershed where corrective efforts should be directed. Unlike chemical measurements that represent ambient conditions in the water body, the macroinvertebrate community composition integrates the water quality conditions over a longer period (months to years) and can identify "hot" spots missed by chemical sampling. If you are interested in more information regarding macroinvertebrate monitoring contact the **LLMP** coordinator.

Fish Condition

The assessment of fish species "health" is another biological indicator of water quality. Because fish are at the top of the food chain, their condition should reflect not only water quality changes that affect them directly but also those changes that affect their food supply. The fish condition index utilized by the **New Hampshire Fish Condition Program** is based on two components; fish scale analysis and a fish condition index.

Like tree trunks, fish scales have annual growth rings (annuli) that reflect their growth history and hence, provide a long-term record of past conditions in the lake. The fish condition index, based upon length and weight measurements, is a good indicator of the fish's health at the time of collection.

The resulting fish condition data can be compared among different lakes or among different years, or the index for a particular species can be compared to standard length-to-weight relationships that have been developed by fisheries biologists for many important fish species. In the end, the "health" of the various fish species reflects the overall water quality in the respective lake or pond.

Zebra Mussels

Zebra mussels (*Dreissena polymorpha*) are non-native, freshwater mollusks. The veligers (larval form) are free swimming, nearly invisible, and profuse. Adult zebra mussel shells are elongate (D-shaped), about the size of a thumbnail and are usually striped. Zebra Mussels are the only freshwater mussel that can attach to objects using sticky threads (byssal threads like those found on the marine blue mussels). These threads allow them to colonize quickly and reach densities of 100,000 or more mussels per square yard. The mussels have an average lifespan of 3.5 to 5 years. A gritty feeling on your boat's hull or other immersed surfaces might indicate that larval zebra mussels have settled.

Zebra mussels originated in the drainage basins of the Black, Caspian, and Aral seas of eastern Europe and have been in western Europe freshwaters since the 1700s. Since first being introduced to North America in 1986, zebra mussels have dramatically altered the balance of freshwater systems and fisheries. These small water dwelling animals have also caused millions of dollars in expenses for industrial water users, drinking water facilities, commercial and recreational boaters, farmers, and other groups and organizations in Canada and the Great Lakes region.

The range occupied by these unwelcome visitors has expanded and continues to grow rapidly. In North America, sightings have been recorded as far north as the Saint Lawrence River near Quebec, as far east as the lower portion of the Hudson River, as far south as the Mississippi River near Vicksburg, and as far west as the Arkansas River in Oklahoma.

In 1993, zebra mussel sightings were confirmed in New England (Lake Champlain). The Lake Champlain population has existed for at least three years, if not longer. Thus, New Hampshire residents and boaters are being encouraged to arm themselves with knowledge about the natural history and geographic spread of the mussels. Interstate boaters and anglers, in particular, should become familiar with boating and fishing practices that decrease the likelihood that zebra mussels will be transferred from an infested water body to an uninfested one.

The infestation risk factor for any particular water body is determined mainly by the amount and type of boat traffic it supports and the chemical characteristics and temperature it maintains. While the goal is to prevent the mussels from becoming established in New England waters, zebra mussels have proven to be adaptable creatures able to survive in a growing range of environmental conditions. Cooperative monitoring activities coordinated by the **New Hampshire Lakes Lay Monitoring Program** will help determine if and when zebra mussels become established in this region. If zebra mussels are found, information about control techniques can help those concerned choose the best method to reduce the destructive impacts of the mussels.

Take responsibilities for our waters. If you've been boating in fresh water outside of New England within the past 10 days and plan to launch locally, please...

Inspect your boat and trailer for weeds. Remove and discard any you find. Zebra mussels are commonly found on aquatic plants in areas of infestation.

Flush the cooling system, bilge areas and live wells with tap water.

Leave unused bait behind and discard bait bucket water away from surface waters.

Keep your boat out of water to dry for 48 hours. If it is visibly fouled by algae, leave it out until the exterior is completely dry **or...**

Wash down the hull at a car wash. Hot (140 degree F) water kills zebra mussels and veligers and high pressure spray helps remove them. Wash fouling off your boat away from water sources!

Learn more about the zebra mussel threat in order to be forewarned of the situation and prevent costly repairs or destructive responses.

Share information, ideas and monitoring tasks with other members of your lake association, watershed council, marina club, conservation commission, angling group or civic organization.

Report any sightings to the **New Hampshire Lakes Lay Monitoring Program**. Preserve specimens in alcohol if possible, note the location where they were found, and send them in to confirm the identification.

To receive more information, request an educational presentation for your next group meeting, become involved in monitoring efforts, or confirm an identification, contact:

Jeff Schloss
Lakes Lay Monitoring Program
55 College Road 109 Pettee Hall
University of New Hampshire
Durham NH 03824-3512
(603) 862-3848

UNIVERSITY OF NEW HAMPSHIRE COOPERATIVE EXTENSION

NEW HAMPSHIRE LAKES LAY MONITORING

Understanding Lake Aging (Eutrophication)

by: Robert Craycraft Educational Program Coordinator,
New Hampshire Lakes Lay Monitoring Program
University of New Hampshire
109 Pettee Hall, Durham, NH 03824
603-862-3546 FAX: 603-862-0107
email: bob.craycraft@unh.edu

and Jeff Schloss UNH Cooperative Extension Water Resources Specialist

A common concern among **New Hampshire Lakes Lay Monitoring Program (NH LLMP)** participants is a perceived increase in the density and abundance of aquatic plants in the shallows, increases in the amount of microscopic plant "algae" growth (detected as greener water), and water transparency decreases; what is known as **eutrophication**. Eutrophication is a natural process by which all lakes age and progress from clear, pristine lakes to green, nutrient enriched lakes on a geological time frame of thousands of years. Much like the fertilizers applied to our lawns, nutrients which enter our lakes stimulate plant growth and culminate in greener (and in turn less clear) waters. Some lakes age at a faster rate than others due to natural attributes: watershed area relative to lake area, slope of the land surrounding the lake, soil type, mean lake depth, etc. Since our New Hampshire lakes were created during the last ice-age which ended about 10,000 years ago, we should have a natural continuum of lakes ranging from pristine to enriched.

Classification criteria are often used to categorize lakes into what are known as **trophic states**, in other words, levels of lake plant and algae productivity or "greenness" Refer to Table 8 below for a summary of commonly used eutrophication parameters.

Table 8: Eutrophication Parameters and Categorization

Parameter	Oligotrophic "pristine"	Mesotrophic "transitional"	Eutrophic "enriched"
Chlorophyll a (ug/l) *	<3.0	3.0-7.0	>7.0
Water Transparency (meters) *	>4.0	2.5-4.0	<2.5
Total Phosphorus (ug/l) *	<15.0	15.0-25.0	>25.0
Dissolved Oxygen (saturation) #	high to moderate	moderate to low	low to zero
Macroscopic Plant (Weed) Abundance	low	moderate	high

*** Denotes classification criteria employed by Forsberg and Ryding (1980).**
 # Denotes dissolved oxygen concentrations near the lakebottom.

Oligotrophic lakes are considered "unproductive" pristine systems and are characterized by high water clarities, low nutrient concentrations, low algae concentrations, minimal levels of aquatic plant "weed" growth, and high dissolved oxygen concentrations near the lakebottom. **Eutrophic** lakes are considered "highly productive" enriched systems characterized by low water transparencies, high nutrient concentrations, high algae concentrations, large stands of aquatic plants and very low dissolved oxygen concentrations near the lakebottom. **Mesotrophic** lakes have qualities between those of oligotrophic and eutrophic lakes and are characterized by moderate water transparencies, moderate nutrient concentrations, moderate algae growth, moderate aquatic plant "weed" growth and decreasing dissolved oxygen concentrations near the lakebottom.

Is a pristine, oligotrophic, lake "better than" an enriched, eutrophic, lake? Not necessarily! As indicated above, lakes will naturally exhibit varying degrees of productivity. Some lakes will naturally be more susceptible to eutrophication than others due to their natural attributes and in turn have aged more rapidly. This is not necessarily a bad thing as our best bass fishing lakes tend to be more mesotrophic to eutrophic than oligotrophic and an ultra-oligotrophic lake (extremely pristine) will not support a very healthy cold water fishery. However, human related activities can augment the aging process (what is known as cultural eutrophication) and result in a transition from a pristine system to an enriched system in tens of years rather than the natural transitional period which should take thousands of years. Cultural eutrophication is particularly a concern for northern New England lakes where large tracts of forested lands are being developed, culminating in an increased susceptibility of these lakes to sediment and nutrient loadings which augment the eutrophication process.

Additionally, other pollutants such as heavy metals, herbicides, insecticides and petroleum products might also affect your lake's "health". A "healthy" lake, as far as eutrophication is concerned, is one in which the various aquatic plants and animals are minimally impacted so that nutrients and other materials are processed efficiently. We can liken this process to a well managed pasture: nutrients grow grasses and other plants that are eaten by grazers like cows and sheep. As long as producers and grazers are balanced, a good amount of nutrients can be processed through the system. Impact the grazers and the grass will overgrow and nuisance weeds will appear, even if nutrients remain the same. In a lake, the producers are the algae and aquatic weeds while the grazers are the microscopic animals (**zooplankton**) and aquatic insects. These organisms can be very susceptible to a wide range of pollutants at very low concentrations. If impacted, the lake can become much more productive and the fishery will be impacted as well since these same organisms are an important food source for most fish at some stage of their life.

Development upon the landscape can negatively affect water quality in a number of ways:

- <u>Removal of shoreside vegetation and loss of wetlands</u> - shoreside vegetation (what is known as **riparian vegetation**) and wetlands provide a protective buffer that "traps" pollutants before reaching the lake. These buffers remove materials both chemically (through biological uptake) and physically (settling materials out). As riparian buffers are removed and wetlands lost, pollutant materials are more likely to enter the lake and in turn, favor declining water quality.

- Excessive fertilizer applications - fertilizers entering the lake can stimulate aquatic plant and algal growth and in extreme cases result in noxious algal blooms. Increases in algal growth tend to diminish water transparency and under extreme cases culminate in surface "scums" that can wash up on the shoreline and can also produce unpleasant smells as the material decomposes. Excessive nutrient concentrations also favor algal forms known to produce toxins which irritate the skin and under extreme conditions, are dangerous when ingested.

- Increased organic matter loading - organic matter (leaves, grass clippings, etc.) are a major source of nutrients in the aquatic environment. As the vegetative matter decomposes nutrients are "freed up" and can become available for aquatic plant and algal growth. In general, we are not concerned with this material entering the lake naturally (leaf senescence in the fall) but rather excessive loading of this material as occurs when residents dump or rake leaf litter and grass clippings into the lake. This material not only provides large nutrient reserves which can stimulate aquatic plant and algal growth but also makes great habitat for leaches and other potentially undesirable organisms in swimming areas.

- Septic problems - faulty septic systems are a big concern as they can be a primary source of water pollution around our lakes. Septic systems are loaded with nutrients and can also be a health threat when not functioning properly.

- Loss of vegatative cover and the creation of impervious surfaces - A forested watershed offers the best protection against pollutant runoff. Trees and tall vegetation intercept heavy rains that can erode soils and surface materials. The roots of these plants keep the soils in place, process nutrients and absorb moisture so the soils do not wash out. Impervious surfaces (paved roads, parking lots, building roofs, etc.) reduce the water's capacity to infiltrate into the ground, and in turn, go through nature's water purification system. As water seeps into the soil, pollutants are removed from the runoff through absorption onto soil particles. Biological processes detoxify substances and/or immobilize substances. Surface water runoff over impervious surfaces also increases water velocities which favor the transport of a greater load of suspended and dissolved pollutants into your lake.

How can you minimize your water quality impacts?

- Minimize fertilizer applications whenever possible. Most people apply far more fertilizers than necessary, with the excess eventually draining into your lake. This not only applies to those immediately adjacent to the lake but to everybody in the watershed. Pollutants in all areas of the watershed will ultimately make their way into your lake. Have your soil tested (the UNH Soils Analytical Laboratory offers soil testing for a nominal fee, contact your county UNH Cooperative Extension Office for further information) to find out how much fertilizer and what type you really need. Sometimes just an application of crushed lime will release enough nutrients to fit the bill. If you do use fertilizer try to use low phosphorus, slow release nitrogen varieties.

- Don't dump leaf litter or leaves into the lake. Compost the material or take it to a proper waste disposal center. Do not fill in wetland areas. Do not create or enhance beach areas with sand (contains phosphorus, smothers aquatic habitat, fills in lake as it gets transported away by currents and wind).
- Septic systems will not function efficiently without the proper precautionary maintenance. Have your septic system inspected every two to four years and pumped out when necessary. Since the septic system is such an expensive investment often costing around $10,000 for a complete overhaul, it is advantageous to assure proper care is taken to prolong the system's life. Additionally, following proper maintenance practices will reduce water quality degradation. Refer to:

  Septic Systems, How they work and how to keep them working. $1.00/ea University of New Hampshire Publications Center (603) 862-2346

  Pipeline: Fall 1995 Vol. 6, No. 4. Maintaining Your Septic System-A Guide for Homeowners. ($0.20 ea. plus shipping & handling). 1-800-624-8301
- Maintain shoreside (riparian) vegetative cover when new construction is undertaken. For those who have pre-existing houses but lack vegetative buffers, consider shoreline plantings aimed at diminishing the pollution load into your lake. Refer to:

  Planting Shoreland Areas (no charge) University of New Hampshire Cooperative Extension Publication Center. (603) 862-2346

  A Guide to Developing and Re-Developing Shoreland Property in New Hampshire: A Blueprint to Help You Live by the Water. North Country Resource Conservation and Development Area, Inc. 103 Main Street-Suite #1,. Meredith NH 03253-9266 (603) 279-6546

  Buffers for Wetlands and Surface Waters: A Guidebook for New Hampshire Municipalities. Audobon Society of New Hampshire. 3 Silk Farm Road, Concord NH 03301 (603) 224-9909 (free for towns, $5.00 for others).
- If you have shoreland property review the New Hampshire Comprehensive Shoreland Protection Act (CSPA). The CSPA sets legal regulations aimed at protecting water quality If you have any questions regarding the act or need further information contact the *Shoreline Protection Act Coordinator at* (603) 271-3503.

Biotoxins: Toxic Chemicals Produced by Cyanobacteria

By: James F. Haney and John J. Sasner
UNH Center for Freshwater Biology

This is an expanded version of an article that appeared in the February 2000 issue of LAKESIDE: a publication of the New Hampshire Lakes Association.

Last summer, George Linscott walked Sam and Magic along the western shore of Lake Champlain. The Labrador retrievers played in the water, but shortly thereafter showed signs of distress. The dogs were rushed to a veterinarian and died later that day. Samples of the water tested indicated the likely cause of the deaths was a toxin produced by *Anabaena*, a type of cyanobacteria, formerly named blue-green algae. High on an alpine meadow in Switzerland cattle die after drinking from what was thought to be a pristine stream. Once again cyanobacteria appeared to be the culprit. These are recent examples of the growing number of cases of cyanobacteria-related deaths of pets and livestock reported worldwide.

Cyanobacteria have been long recognized as problem "algae" in lakes. In addition to imparting bad tastes and odors to water, these microscopic lake inhabitants also produce highly toxic chemicals called biotoxins. Three of the most common toxic cyanobacteria in New Hampshire lakes are *Anabaena*, *Aphanizomenon* and *Microcystis*, commonly referred to as "Annie, Phannie and Mike." Curiously, their toxicity may change, depending on the lake and time of year and some strains never produce toxins.

Lake biotoxins consist of a variety of chemical compounds. They are often categorized according to their mode of toxicity as (1) neurotoxins, those that interfere with the conduction and transmission of nerve impulses and (2) hepatotoxins, those that cause hemorrhaging of the liver tissue. Whereas the effects of the liver toxins may be seen after hours or days, acute poisoning by neurotoxins may show almost immediate symptoms, such as a tingling sensation followed by paralysis. Both types of biotoxins may be fatal in large doses. Because of widespread damage caused by "red tides", there is much more known about toxic marine algae. There are, however, surprising similarities between freshwater and marine biotoxins. For example, researchers at the University of New Hampshire discovered that neosaxitoxin, a neurotoxin produced by *Aphanizomenon* (Phannie) is nearly identical to the toxins produced by marine dinoflagellates that cause "red tides" and paralytic shellfish poisons.

Cyanobacteria occur naturally in virtually all lakes. Problems most often occur when excessive nutrients are added to lakes, causing a burst of growth in populations of cyanobacteria and the formation of conspicuous "blooms" along the lakeshore, where they appear as a green film or as blue-green flakes floating just below the surface. When toxic, such accumulations pose the greatest health threat if the water containing the bloom is ingested. Direct contact with the skin may cause skin irritations, but does not usually cause serious health effects.

The field of biotoxins research is relatively young and many questions remain unanswered. For example, it is not known what conditions cause certain cyanobacteria to become toxic nor how they may benefit from producing such substances. Since cyanobacteria are among the oldest organisms on earth, these toxins may have evolved long before the presence of other species, such as fish and humans. It is thought that some toxic compounds may in fact be used by cyanobacteria to assist in gathering scarce nutrients necessary for growth, such as iron and carbon.

Using improved methods of detection, a research team from the Biotoxins Lab at the UNH Center for Freshwater Biology, completed its first field season last summer investigating toxins in 50 lakes throughout New Hampshire. The focus of this study was to determine the types of lakes and regions of the state in which the hepatotoxin microcystin are present and also whether these toxins bioaccumulate in the food web of lakes, such as in the crayfish, mussels and fish. Although samples are still being processed and this work has not yet been fully analyzed, preliminary results show that microcystins occur in many lakes throughout the state. Also, the level of microcystins is correlated with the concentration of phosphorus in lake water. This suggests that eutrophication may have a direct linkage to the abundance of biotoxins in our lakes. These findings provide yet another important reason to protect our waters from nutrient pollution and emphasize the need to continually monitor the health of our lakes.

Should New Hampshire lake users be concerned about biotoxins? In most of our lakes concentrations of biotoxins are well below levels that pose a health threat. When swimming it would be wise to avoid areas of the lake where a scum of cyanobacteria have collected. It is especially important to prevent children from playing in such areas, as they may accidentally drink the contaminated lake water. Likewise, pets should be refrained from drinking from areas with conspicuous accumulations of blue-green bacteria.

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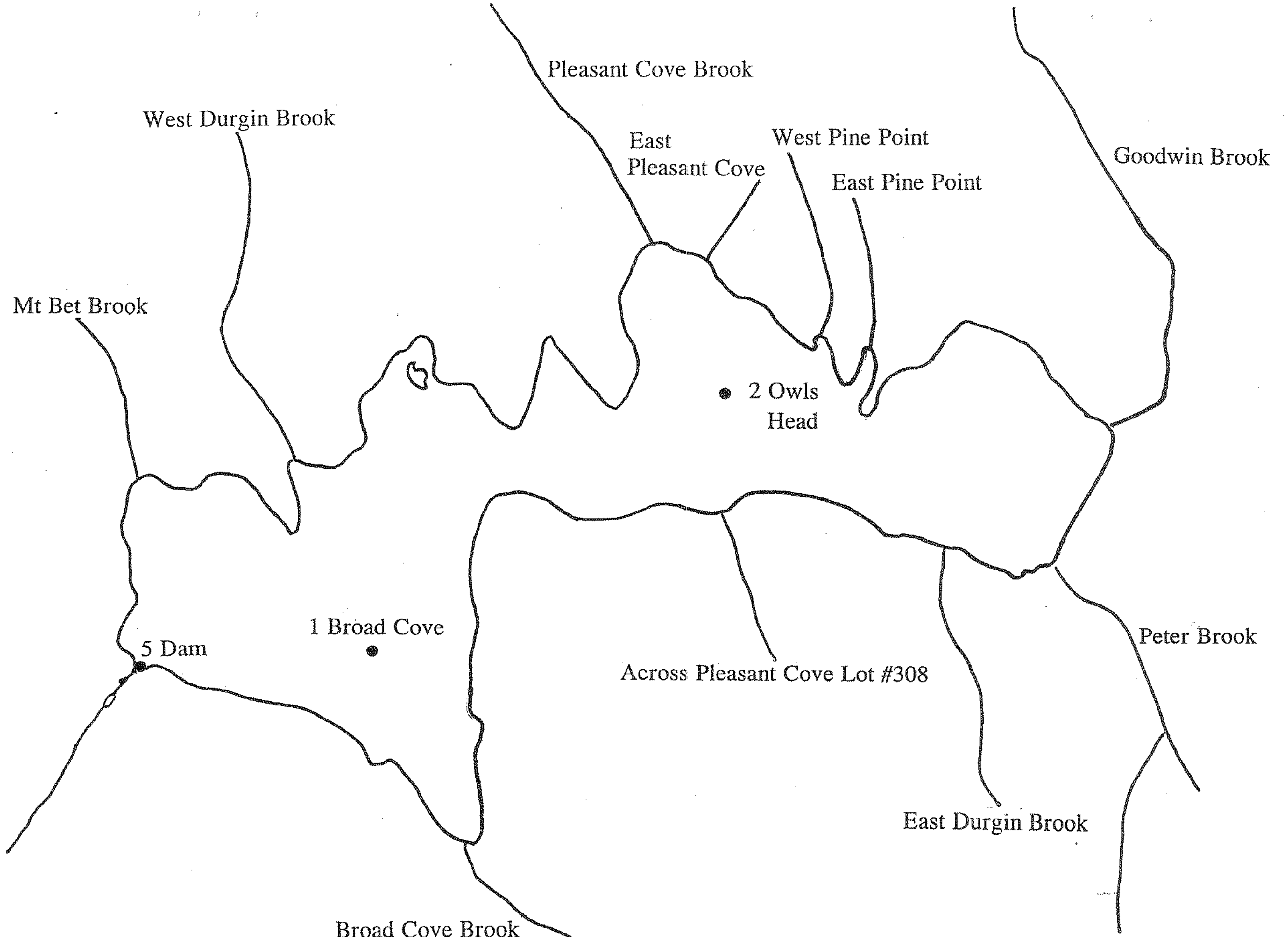
REPORT FIGURES

Figure 9. Location of the 1999 Merrymeeting Lake deep sampling stations, 1 Broad Cove, 2 Owls Head and 3 East End, New Durham, New Hampshire.

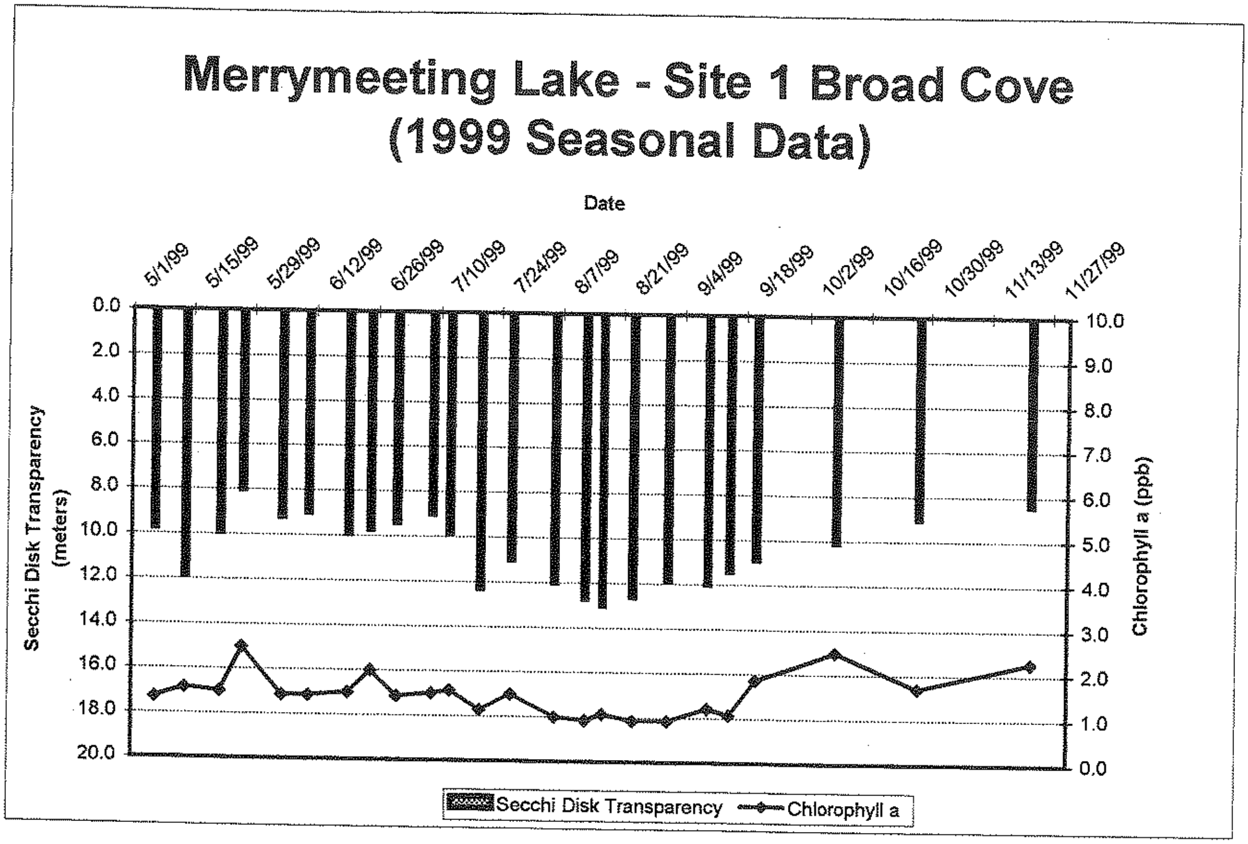


MERRYMEETING LAKE

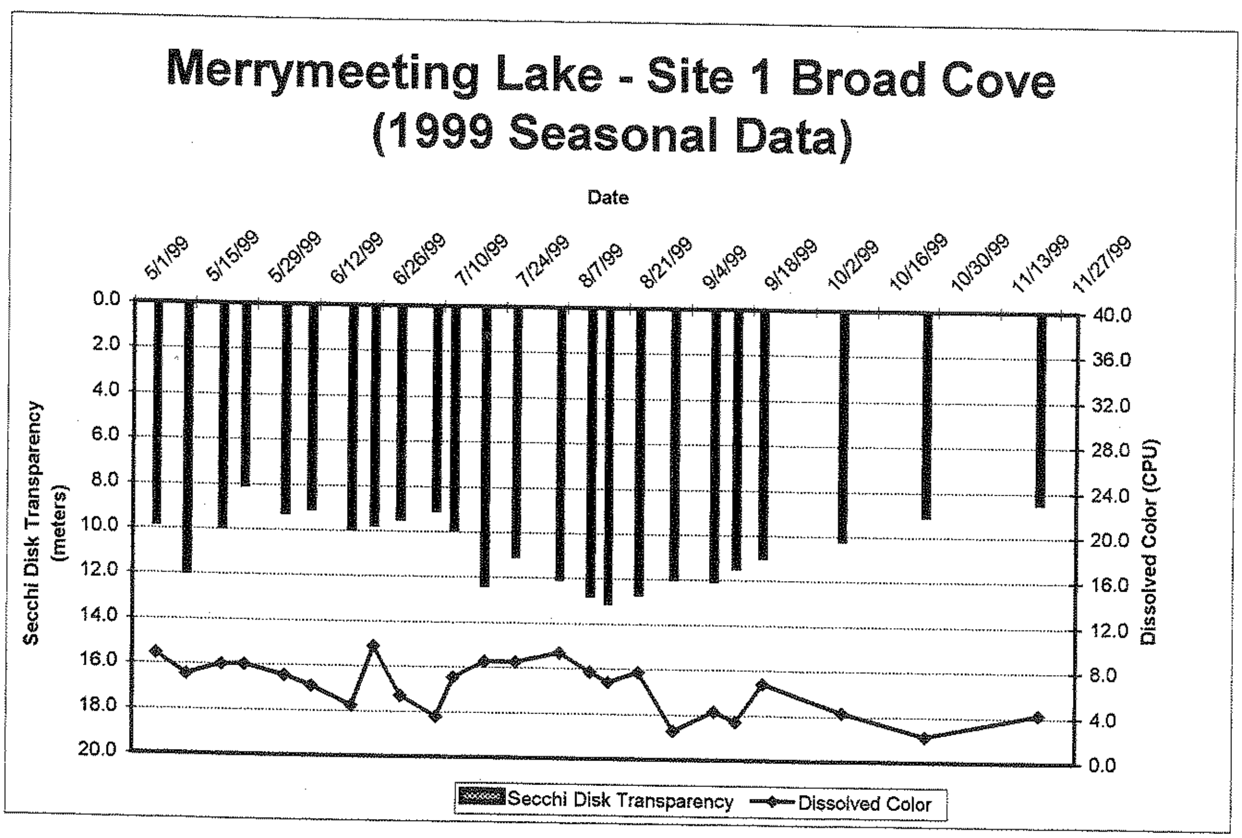
Figure 10. Merrymeeting Lake, 1999. Seasonal Secchi Disk (water transparency) and chlorophyll *a* trends for Site 1 Broad Cove. The Secchi Disk transparency data are reported to the nearest 0.1 meters while the chlorophyll *a* data are reported to the nearest 0.1 parts per billion (ppb).

Figure 11. Merrymeeting Lake, 1999. Seasonal Secchi Disk (water transparency) and dissolved color trends for Site 1 Broad Cove. The Secchi Disk transparency data are reported to the nearest 0.1 meters while the dissolved color data are reported to the nearest 0.1 chloroplatinate unit (CPU).

Note: the overlay of the Secchi Disk data with chlorophyll *a* and dissolved color data is intended to provide a visual depiction of the impacts of chlorophyll *a* and dissolved color on water transparency measurements (e.g. higher chlorophyll a and dissolved color concentrations often correspond to shallower water transparencies).



Merrymeeting Lake - Site 1 Broad Cove
(1999 Seasonal Data)
Date
5/1/99
5/15/99
5/29/99
6/12/99
6/26/99
7/10/99
7/24/99
8/7/99
8/21/99
9/4/99
9/18/99
10/2/99
10/16/99
10/30/99
11/13/99
11/27/99
Secchi Disk Transparency (meters)
Chlorophyll a (ppb)
Secchi Disk Transparency
Chlorophyll a

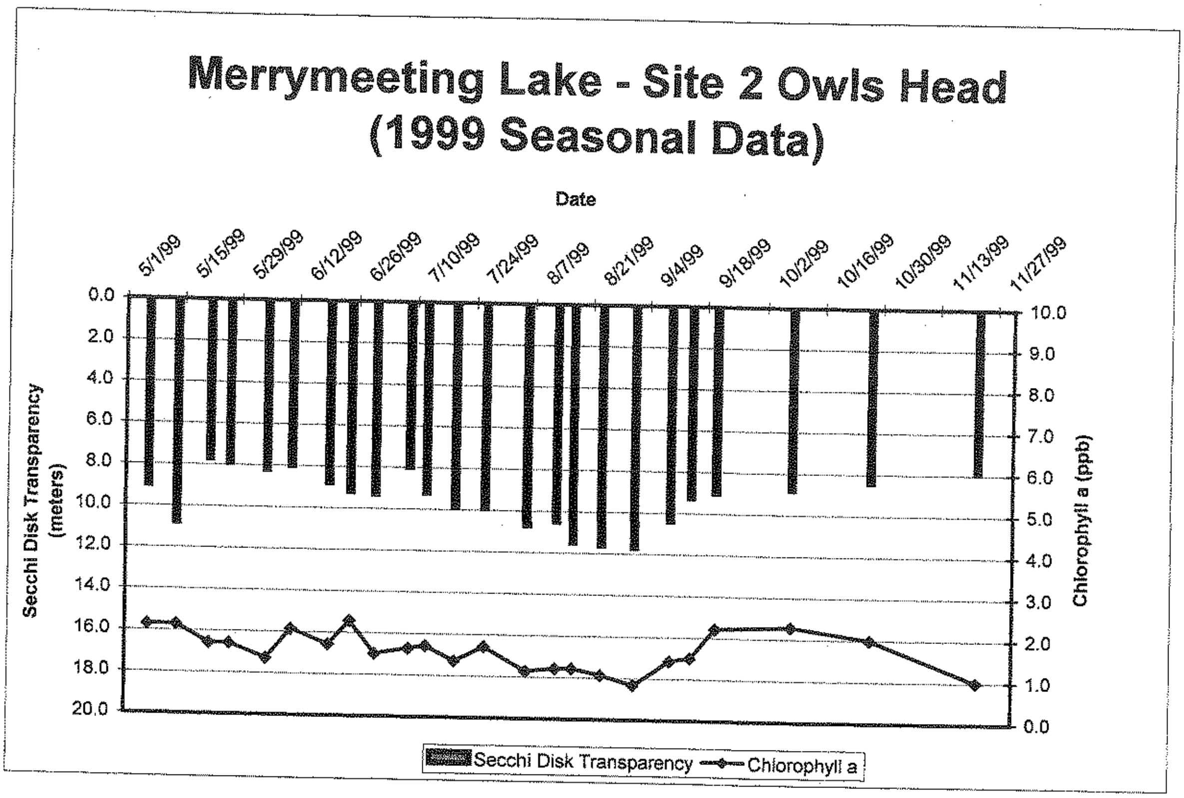


Merrymeeting Lake - Site 1 Broad Cove
(1999 Seasonal Data)
Date
5/1/99
5/15/99
5/29/99
6/12/99
6/26/99
7/10/99
7/24/99
8/7/99
8/21/99
9/4/99
9/18/99
10/2/99
10/16/99
10/30/99
11/13/99
11/27/99
Secchi Disk Transparency (meters)
Dissolved Color (CPU)
Secchi Disk Transparency
Dissolved Color

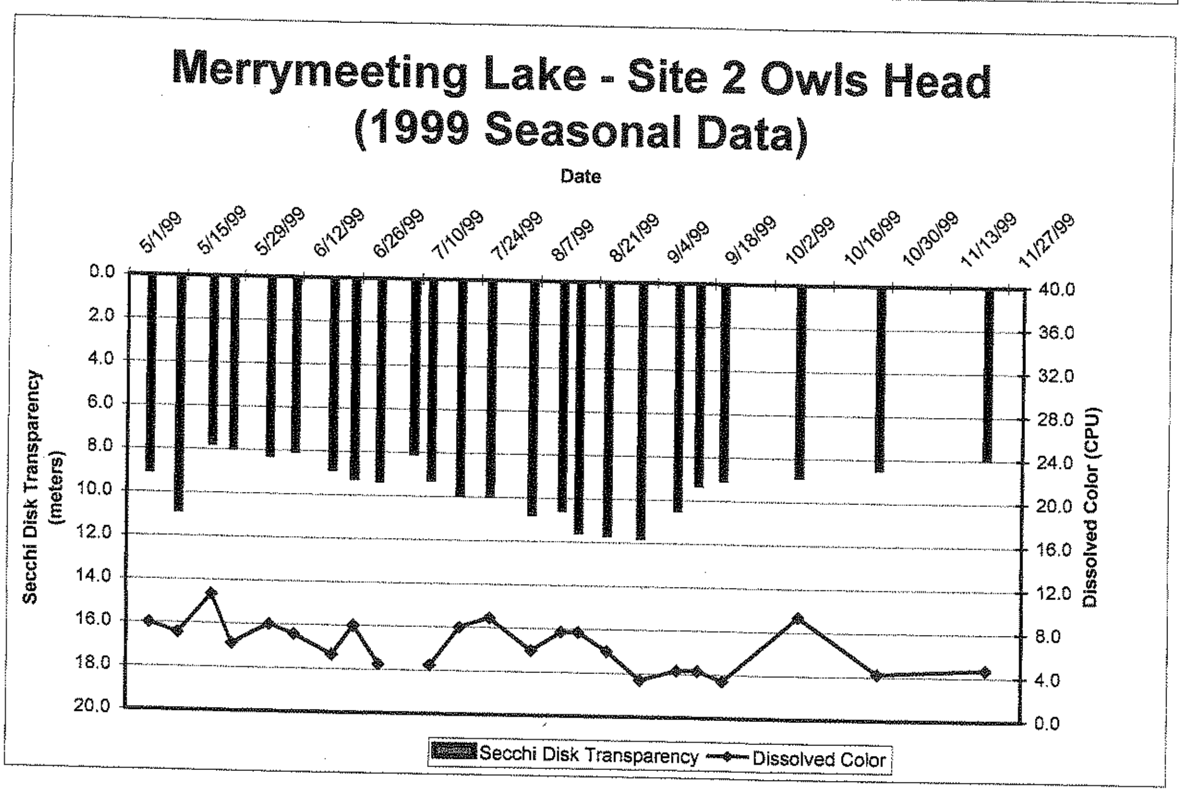
Figure 12. Merrymeeting Lake, 1999. Seasonal Secchi Disk (water transparency) and chlorophyll *a* trends for Site 2 Owls Head. The Secchi Disk transparency data are reported to the nearest 0.1 meters while the chlorophyll *a* data are reported to the nearest 0.1 parts per billion (ppb).

Figure 13. Merrymeeting Lake, 1999. Seasonal Secchi Disk (water transparency) and dissolved color trends for Site 2 Owls Head. The Secchi Disk transparency data are reported to the nearest 0.1 meters while the dissolved color data are reported to the nearest 0.1 chloroplatinate unit (CPU).

Note: the overlay of the Secchi Disk data with chlorophyll *a* and dissolved color data is intended to provide a visual depiction of the impacts of chlorophyll *a* and dissolved color on water transparency measurements (e.g. higher chlorophyll a and dissolved color concentrations often correspond to shallower water transparencies).



Merrymeeting Lake - Site 2 Owls Head
(1999 Seasonal Data)
Date
5/1/99
5/15/99
5/29/99
6/12/99
6/26/99
7/10/99
7/24/99
8/7/99
8/21/99
9/4/99
9/18/99
10/2/99
10/16/99
10/30/99
11/13/99
11/27/99
Secchi Disk Transparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Chlorophyll a (ppb)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Secchi Disk Transparency
Chlorophyll a

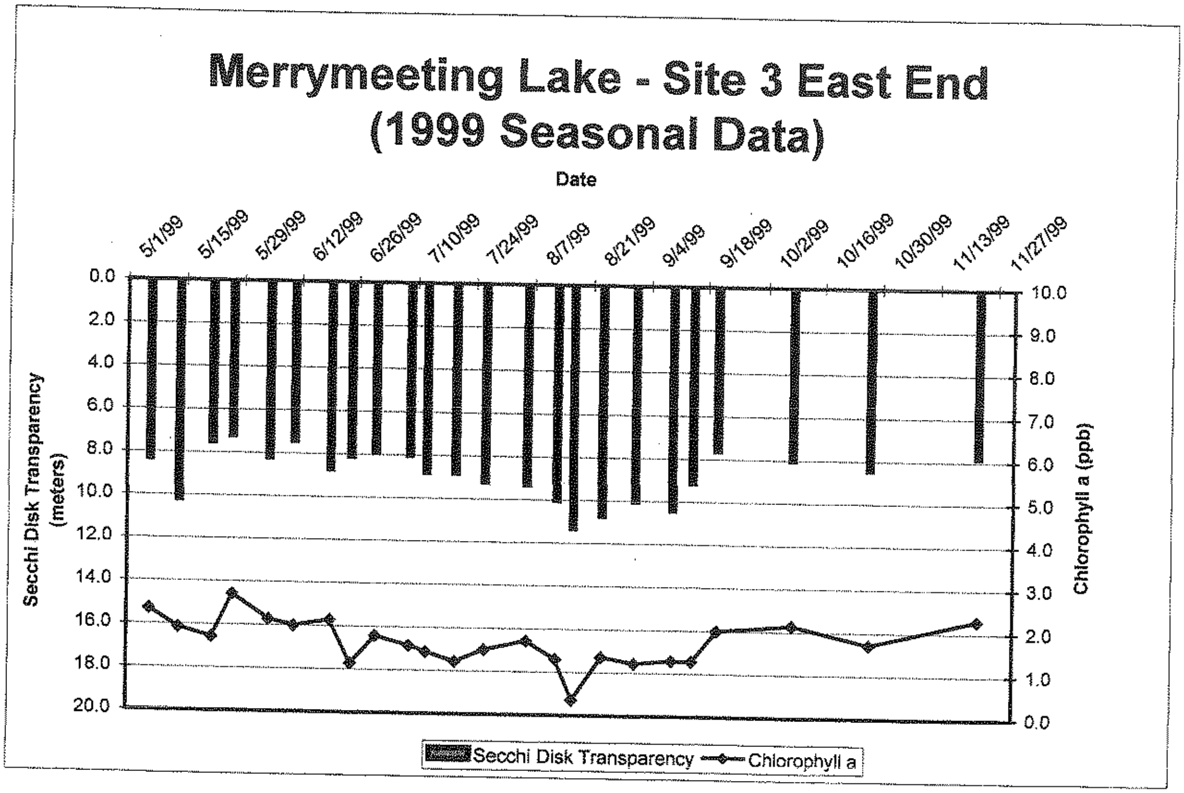


Merrymeeting Lake - Site 2 Owls Head
(1999 Seasonal Data)
Date
5/1/99
5/15/99
5/29/99
6/12/99
6/26/99
7/10/99
7/24/99
8/7/99
8/21/99
9/4/99
9/18/99
10/2/99
10/16/99
10/30/99
11/13/99
11/27/99
Secchi Disk Transparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Dissolved Color (CPU)
40.0
36.0
32.0
28.0
24.0
20.0
16.0
12.0
8.0
4.0
0.0
Secchi Disk Transparency
Dissolved Color

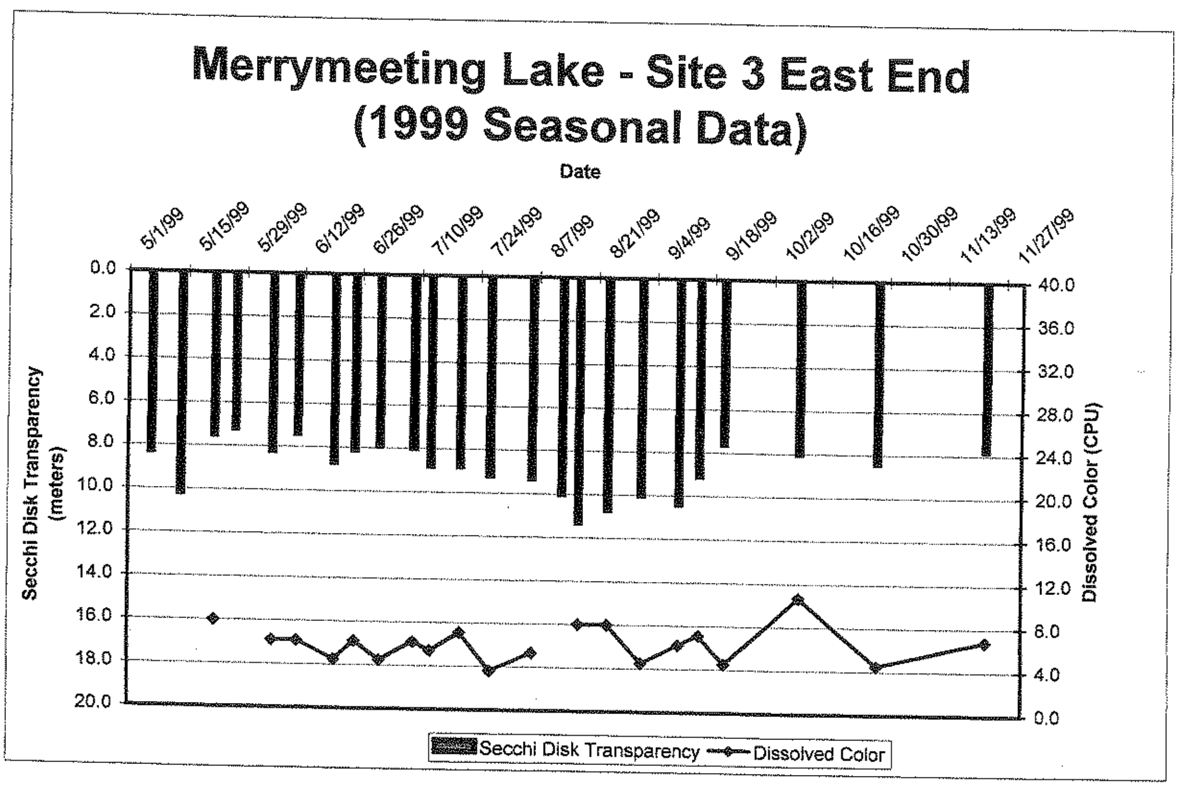
Figure 14. Merrymeeting Lake, 1999. Seasonal Secchi Disk (water transparency) and chlorophyll *a* trends for Site 3 East End. The Secchi Disk transparency data are reported to the nearest 0.1 meters while the chlorophyll *a* data are reported to the nearest 0.1 parts per billion (ppb).

Figure 15. Merrymeeting Lake, 1999. Seasonal Secchi Disk (water transparency) and dissolved color trends for Site 3 East End. The Secchi Disk transparency data are reported to the nearest 0.1 meters while the dissolved color data are reported to the nearest 0.1 chloroplatinate unit (CPU).

Note: the overlay of the Secchi Disk data with chlorophyll *a* and dissolved color data is intended to provide a visual depiction of the impacts of chlorophyll *a* and dissolved color on water transparency measurements (e.g. higher chlorophyll a and dissolved color concentrations often correspond to shallower water transparencies).



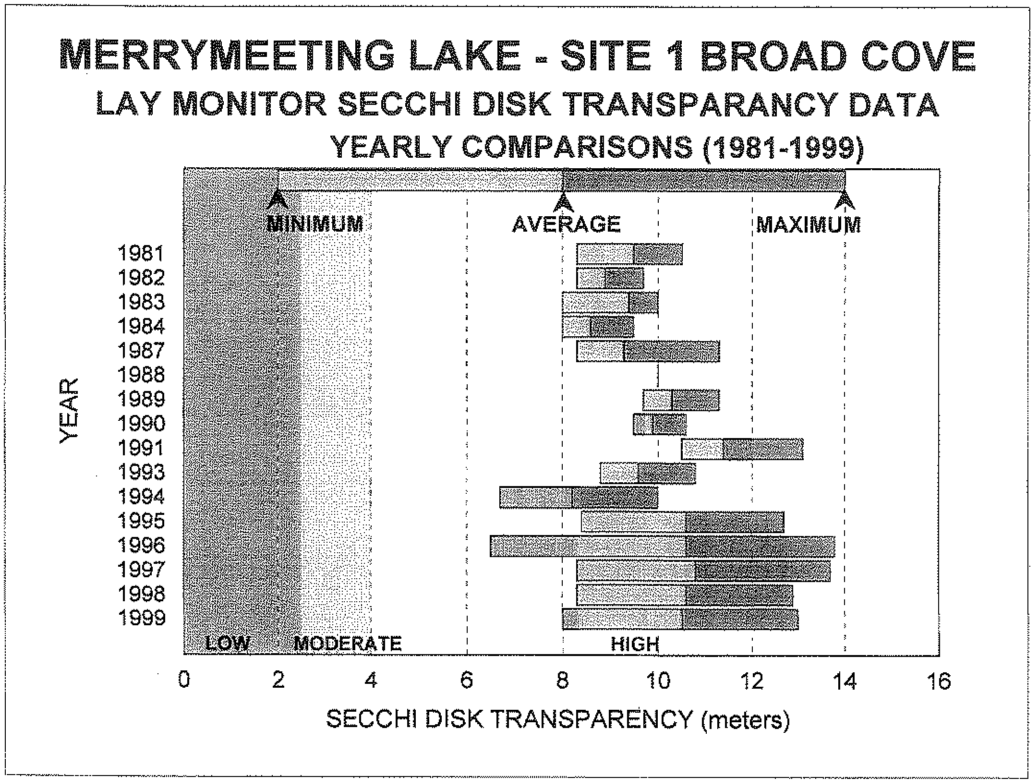
Merrymeeting Lake - Site 3 East End
(1999 Seasonal Data)
Date
5/1/99
5/15/99
5/29/99
6/12/99
6/26/99
7/10/99
7/24/99
8/7/99
8/21/99
9/4/99
9/18/99
10/2/99
10/16/99
10/30/99
11/13/99
11/27/99
Secchi Disk Transparency (meters)
Chlorophyll a (ppb)
Secchi Disk Transparency
Chlorophyll a



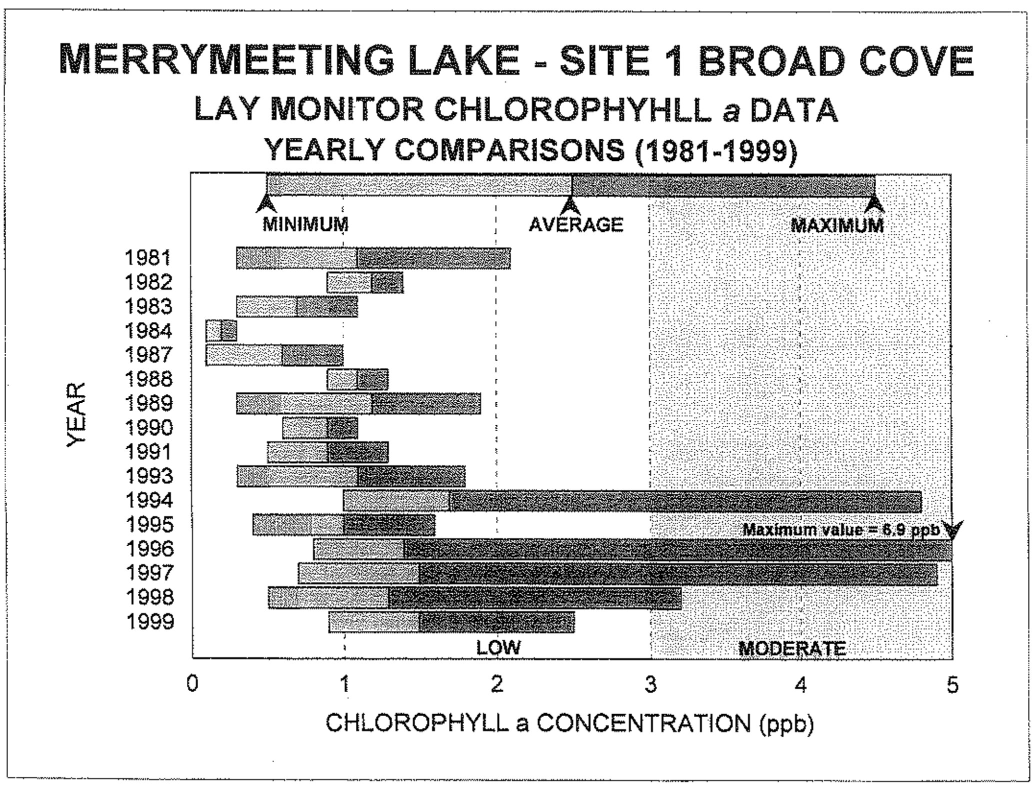
Merrymeeting Lake - Site 3 East End
(1999 Seasonal Data)
Date
5/1/99
5/15/99
5/29/99
6/12/99
6/26/99
7/10/99
7/24/99
8/7/99
8/21/99
9/4/99
9/18/99
10/2/99
10/16/99
10/30/99
11/13/99
11/27/99
Secchi Disk Transparency (meters)
Dissolved Color (CPU)
Secchi Disk Transparency
Dissolved Color

Figure 16. Comparison of the 1999 Merrymeeting Lake, Site 1 Broad Cove, lay monitor Secchi Disk transparency data with historical water quality data collected in conjunction with the New Hampshire Lakes Lay Monitoring Program (1981-1998). The shaded regions on the graph denote the ranges characteristic of low, moderate and high Secchi Disk transparencies. The higher the Secchi Disk transparency the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 17. Comparison of the 1999 Merrymeeting Lake, Site 1 Broad Cove, lay monitor chlorophyll *a* data with historical water quality data collected in conjunction with the New Hampshire Lakes Lay Monitoring Program (1981-1998). The shaded regions on the graph denote the ranges characteristic of low and moderate chlorophyll *a* concentrations. The higher the chlorophyll *a* concentration the greener the water (i.e. more algal growth).



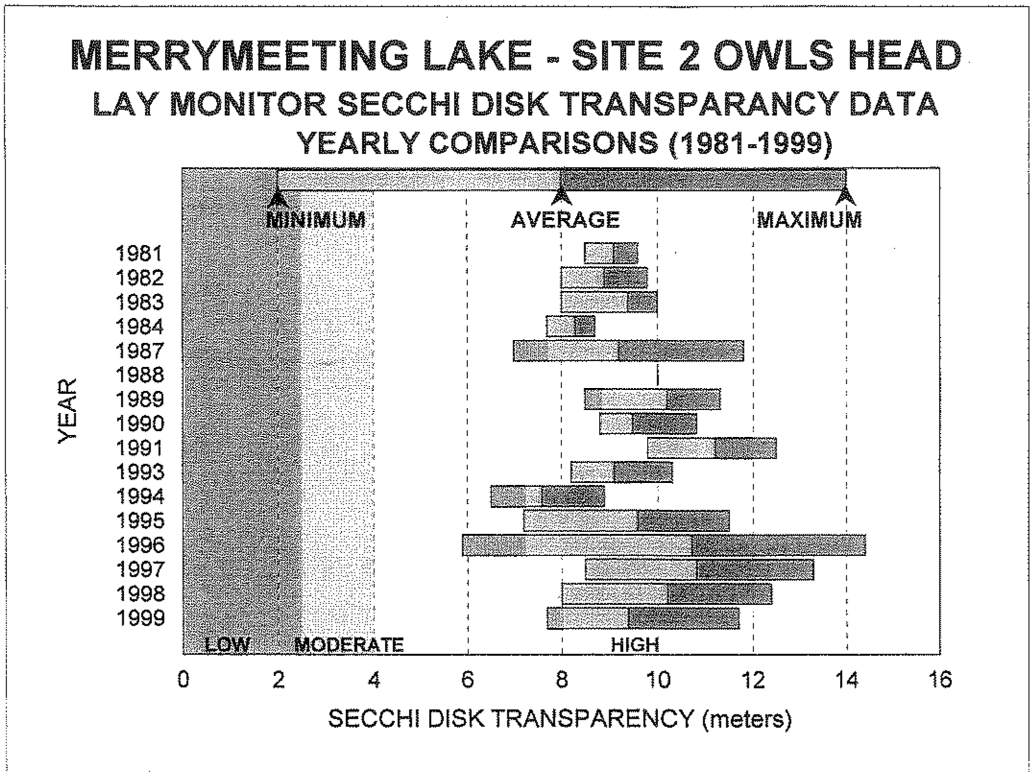
MERRYMEETING LAKE - SITE 1 BROAD COVE
LAY MONITOR SECCHI DISK TRANSPARANCY DATA
YEARLY COMPARISONS (1981-1999)
MINIMUM
AVERAGE
MAXIMUM
YEAR
1981
1982
1983
1984
1987
1988
1989
1990
1991
1993
1994
1995
1996
1997
1998
1999
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
14
16
SECCHI DISK TRANSPARENCY (meters)



MERRYMEETING LAKE - SITE 1 BROAD COVE
LAY MONITOR CHLOROPHYHLL a DATA
YEARLY COMPARISONS (1981-1999)
MINIMUM
AVERAGE
MAXIMUM
YEAR
1981
1982
1983
1984
1987
1988
1989
1990
1991
1993
1994
1995
1996
1997
1998
1999
Maximum value = 6.9 ppb
LOW
MODERATE
0
1
2
3
4
5
CHLOROPHYLL a CONCENTRATION (ppb)

Figure 18. Comparison of the 1999 Merrymeeting Lake, Site 2 Owls Head, lay monitor Secchi Disk transparency data with historical water quality data collected in conjunction with the New Hampshire Lakes Lay Monitoring Program (1981-1998). The shaded regions on the graph denote the ranges characteristic of low, moderate and high Secchi Disk transparencies. The higher the Secchi Disk transparency the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 19. Comparison of the 1999 Merrymeeting Lake, Site 2 Owls Head, lay monitor chlorophyll *a* data with historical water quality data collected in conjunction with the New Hampshire Lakes Lay Monitoring Program (1981-1998). The shaded regions on the graph denote the ranges characteristic of low and moderate chlorophyll *a* concentrations. The higher the chlorophyll *a* concentration the greener the water (i.e. more algal growth).


MERRYMEETING LAKE - SITE 2 OWLS HEAD
LAY MONITOR SECCHI DISK TRANSPARANCY DATA
YEARLY COMPARISONS (1981-1999)
MINIMUM
AVERAGE
MAXIMUM
YEAR
1981
1982
1983
1984
1987
1988
1989
1990
1991
1993
1994
1995
1996
1997
1998
1999
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
14
16
SECCHI DISK TRANSPARENCY (meters)

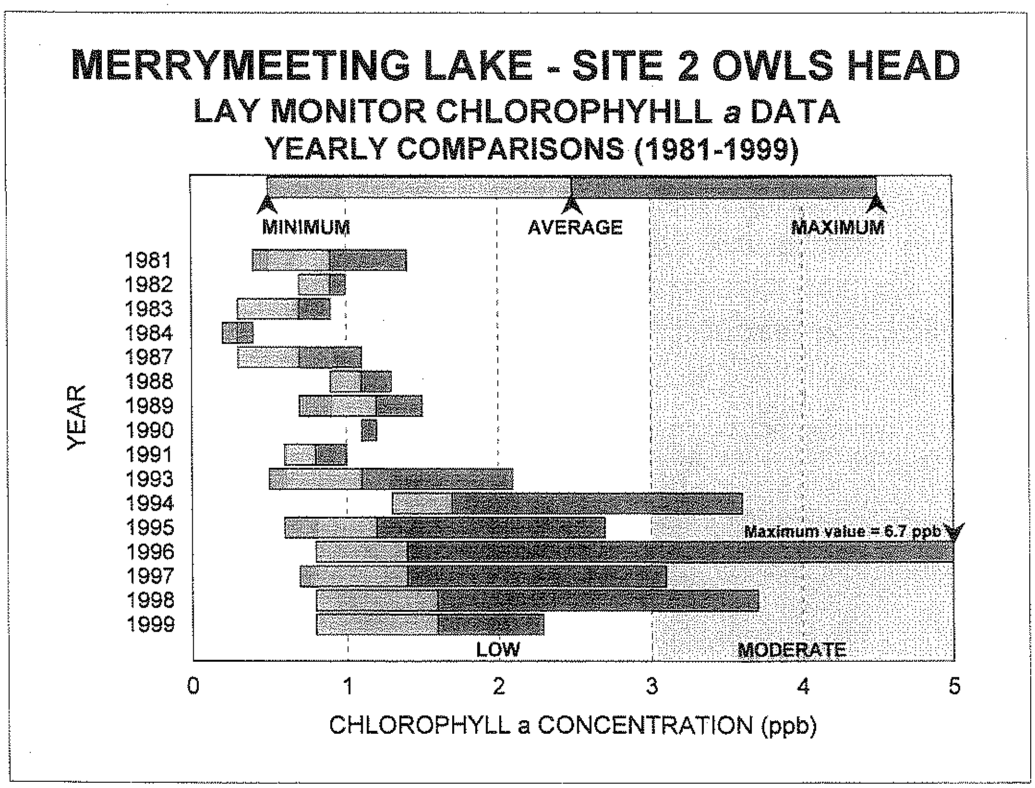
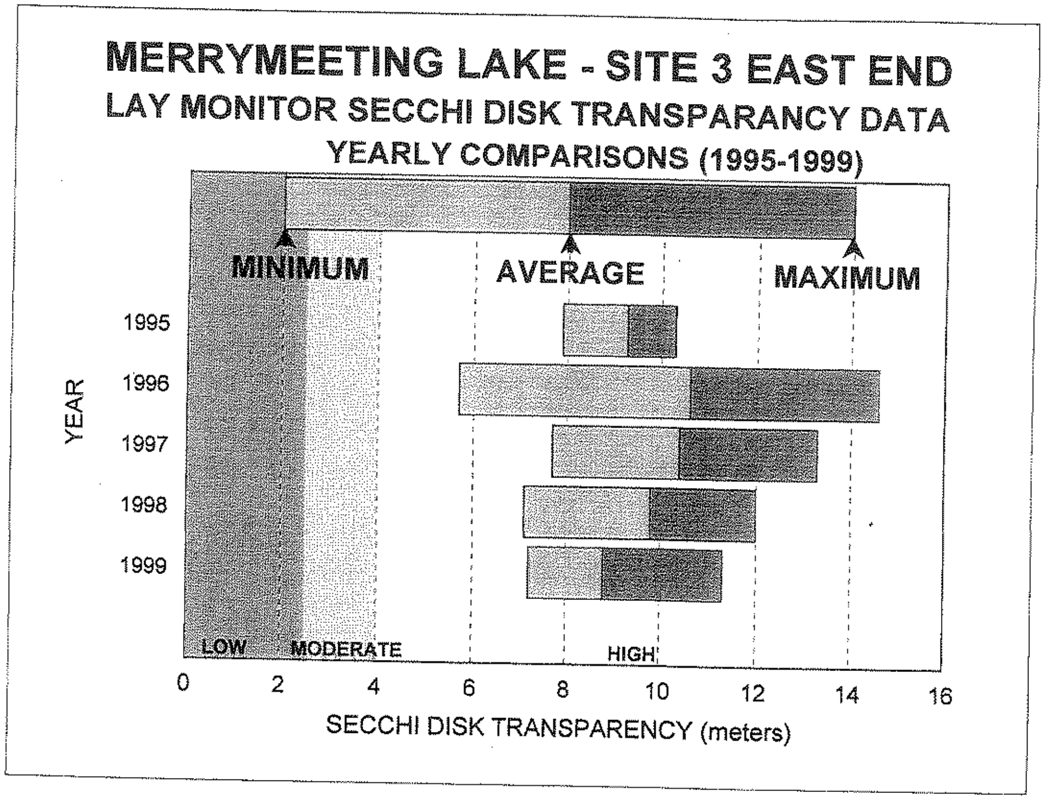

MERRYMEETING LAKE - SITE 2 OWLS HEAD
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1981-1999)
MINIMUM
AVERAGE
MAXIMUM
YEAR
1981
1982
1983
1984
1987
1988
1989
1990
1991
1993
1994
1995
1996
1997
1998
1999
Maximum value = 6.7 ppb
LOW
MODERATE
0
1
2
3
4
5
CHLOROPHYLL a CONCENTRATION (ppb)

Figure 20. Comparison of the 1999 Merrymeeting Lake, Site 3 East End, lay monitor Secchi Disk transparency data with historical water quality data collected in conjunction with the New Hampshire Lakes Lay Monitoring Program (1995-1998). The shaded regions on the graph denote the ranges characteristic of low, moderate and high Secchi Disk transparencies. The higher the Secchi Disk transparency the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 21. Comparison of the 1999 Merrymeeting Lake, Site 3 East End, lay monitor chlorophyll *a* data with historical water quality data collected in conjunction with the New Hampshire Lakes Lay Monitoring Program (1995-1998). The shaded regions on the graph denote the ranges characteristic of low and moderate chlorophyll *a* concentrations. The higher the chlorophyll *a* concentration the greener the water (i.e. more algal growth).


MERRYMEETING LAKE - SITE 3 EAST END
LAY MONITOR SECCHI DISK TRANSPARANCY DATA
YEARLY COMPARISONS (1995-1999)
MINIMUM
AVERAGE
MAXIMUM
YEAR
1995
1996
1997
1998
1999
LOW
MODERATE
HIGH
0
2
4
6
8
10
12
14
16
SECCHI DISK TRANSPARENCY (meters)

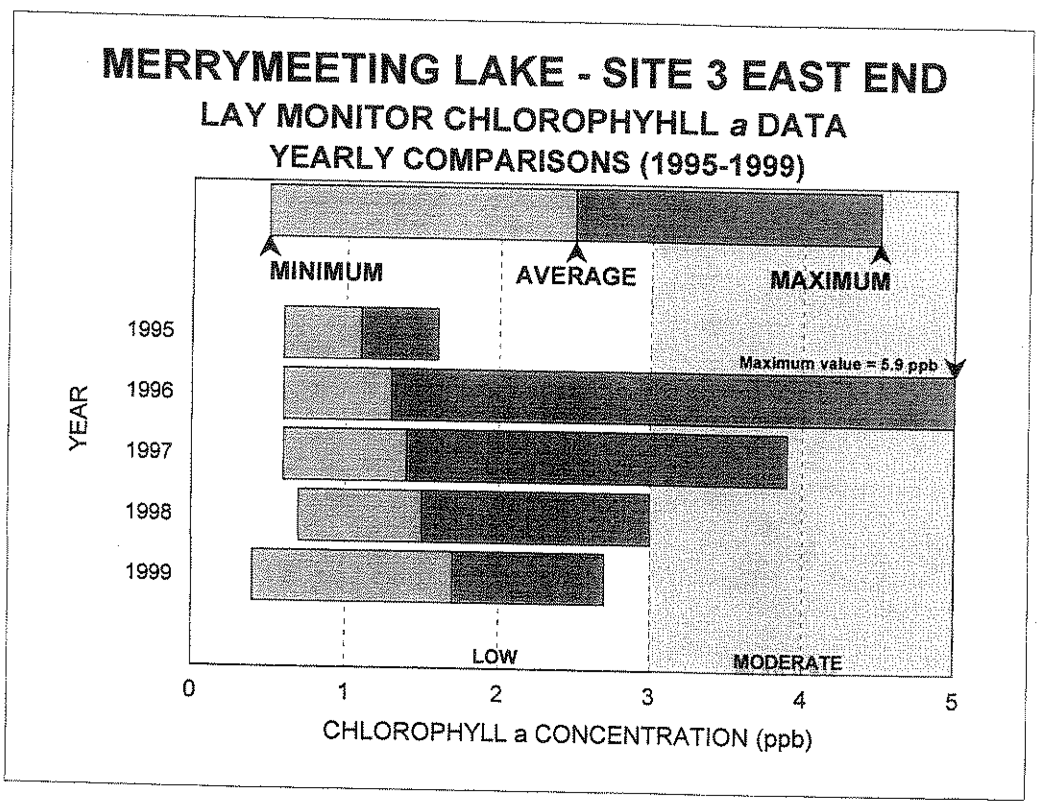
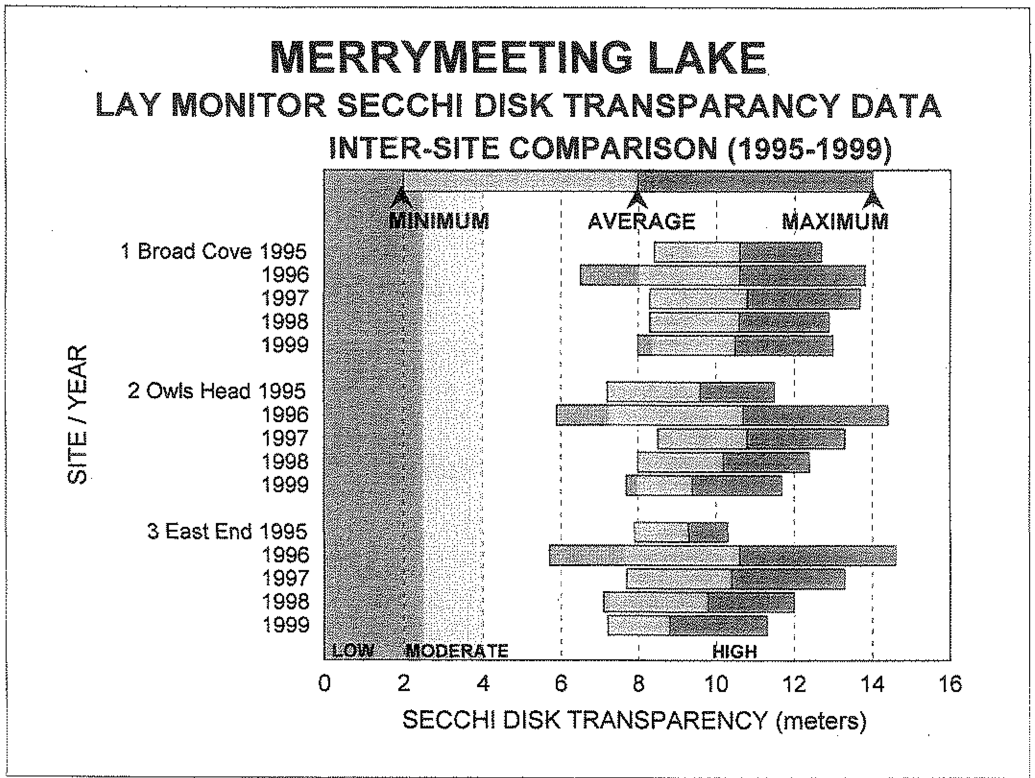

MERRYMEETING LAKE - SITE 3 EAST END
LAY MONITOR CHLOROPHYLL a DATA
YEARLY COMPARISONS (1995-1999)
MINIMUM
AVERAGE
MAXIMUM
Maximum value = 5.9 ppb
YEAR
1995
1996
1997
1998
1999
LOW
MODERATE
0
1
2
3
4
5
CHLOROPHYLL a CONCENTRATION (ppb)

Figure 22. Inter-site comparison of the 1995-1999 Merrymeeting Lake deep sampling station (Sites 1 Broad Cove, 2 Owls Head and 3 East End) volunteer monitor Secchi Disk transparency data collected in conjunction with the New Hampshire Lakes Lay Monitoring Program. The shaded regions on the graph denote the ranges characteristic of low, moderate and high Secchi Disk transparencies. The higher the Secchi Disk transparency the clearer the water. Secchi Disk readings are measured to the nearest tenth (0.1) of a meter.

Figure 23. Inter-site comparison of the 1995-1999 Merrymeeting Lake deep sampling station (Sites 1 Broad Cove, 2 Owls Head and 3 East End) volunteer monitor chlorophyll *a* data collected in conjunction with the New Hampshire Lakes Lay Monitoring Program. The shaded regions on the graph denote the ranges characteristic of low and moderate chlorophyll *a* concentrations. The higher the chlorophyll *a* concentration the greener the water (i.e. more algal growth).


MERRYMEETING LAKE
LAY MONITOR SECCHI DISK TRANSPARANCY DATA
INTER-SITE COMPARISON (1995-1999)
MINIMUM
AVERAGE
MAXIMUM
1 Broad Cove 1995
1996
1997
1998
1999
2 Owls Head 1995
1996
1997
1998
1999
3 East End 1995
1996
1997
1998
1999
SITE / YEAR
LOW
MODERATE
HIGH
0 2 4 6 8 10 12 14 16
SECCHI DISK TRANSPARENCY (meters)

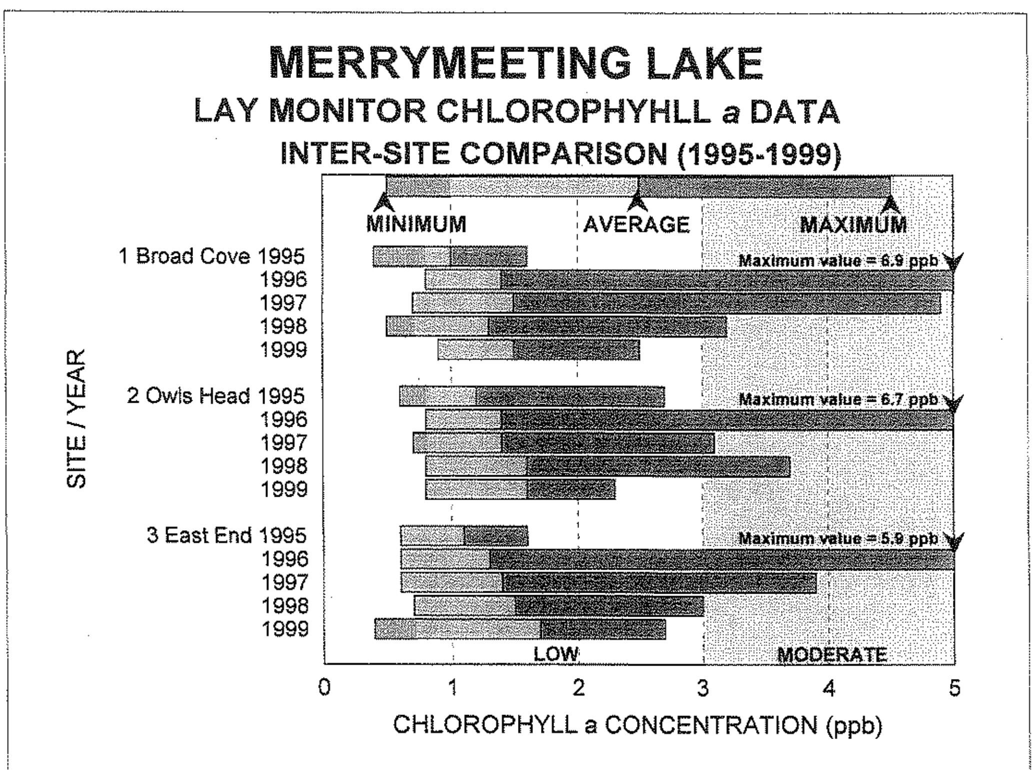
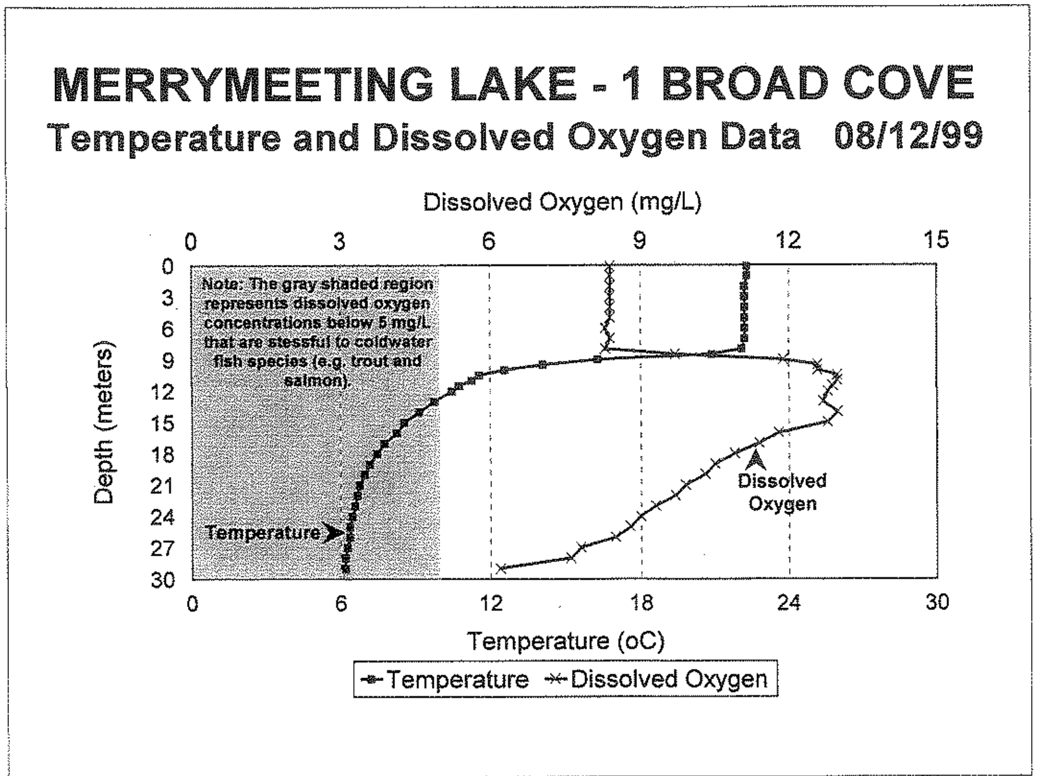

MERRYMEETING LAKE
LAY MONITOR CHLOROPHYLL a DATA
INTER-SITE COMPARISON (1995-1999)
MINIMUM
AVERAGE
MAXIMUM
1 Broad Cove 1995
1996
1997
1998
1999
2 Owls Head 1995
1996
1997
1998
1999
3 East End 1995
1996
1997
1998
1999
Maximum value = 6.9 ppb
Maximum value = 6.7 ppb
Maximum value = 5.9 ppb
SITE / YEAR
LOW
MODERATE
0 1 2 3 4 5
CHLOROPHYLL a CONCENTRATION (ppb)

Figure 24. Temperature and dissolved profiles collected in Merrymeeting Lake, Site 1 Broad Cove, on (A) August 12, 1999 and (B) August 31, 1999. The gray shaded region on the graph denotes dissolved oxygen concentrations stressful to coldwater fish. The temperature and dissolved oxygen data were collected at increments of no greater than one meter and are reported as degrees Centigrade (°C) and parts per million (ppm), respectively.


MERRYMEETING LAKE - 1 BROAD COVE
Temperature and Dissolved Oxygen Data 08/12/99
Dissolved Oxygen (mg/L)
0 3 6 9 12 15
Note: The gray shaded region represents dissolved oxygen concentrations below 5 mg/L that are stessful to coldwater fish species (e.g. trout and salmon).
Depth (meters)
0 3 6 9 12 15 18 21 24 27 30
Temperature
Dissolved Oxygen
0 6 12 18 24 30
Temperature (oC)
Temperature
Dissolved Oxygen

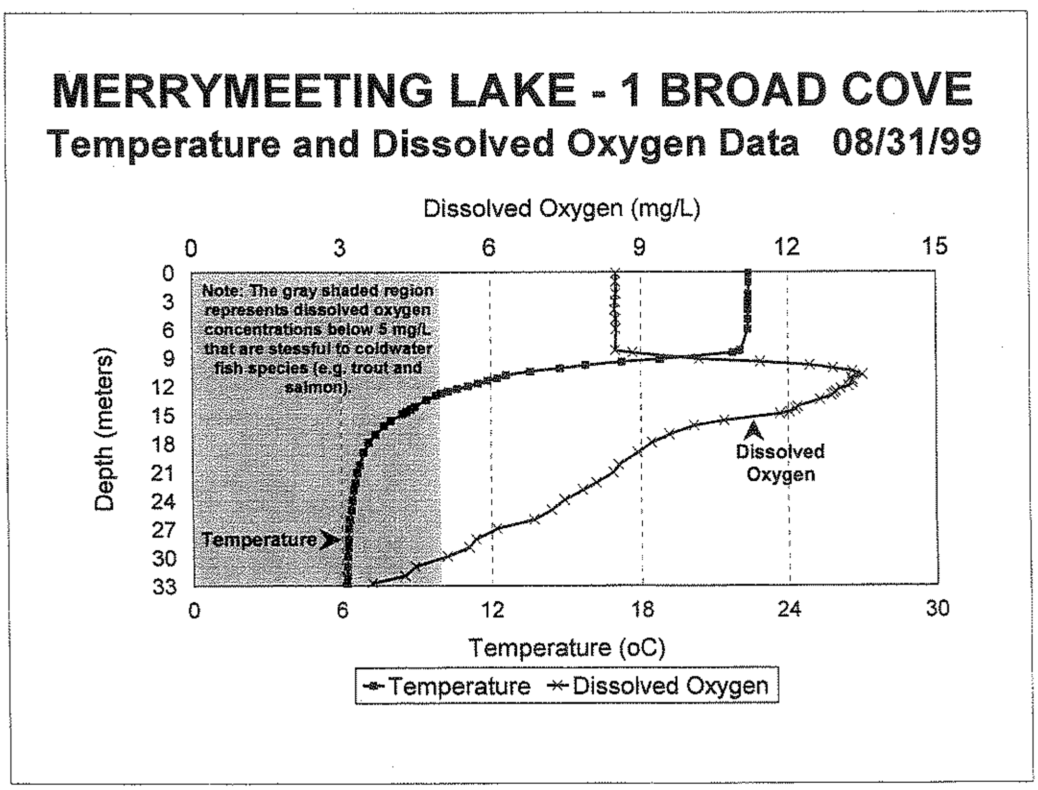
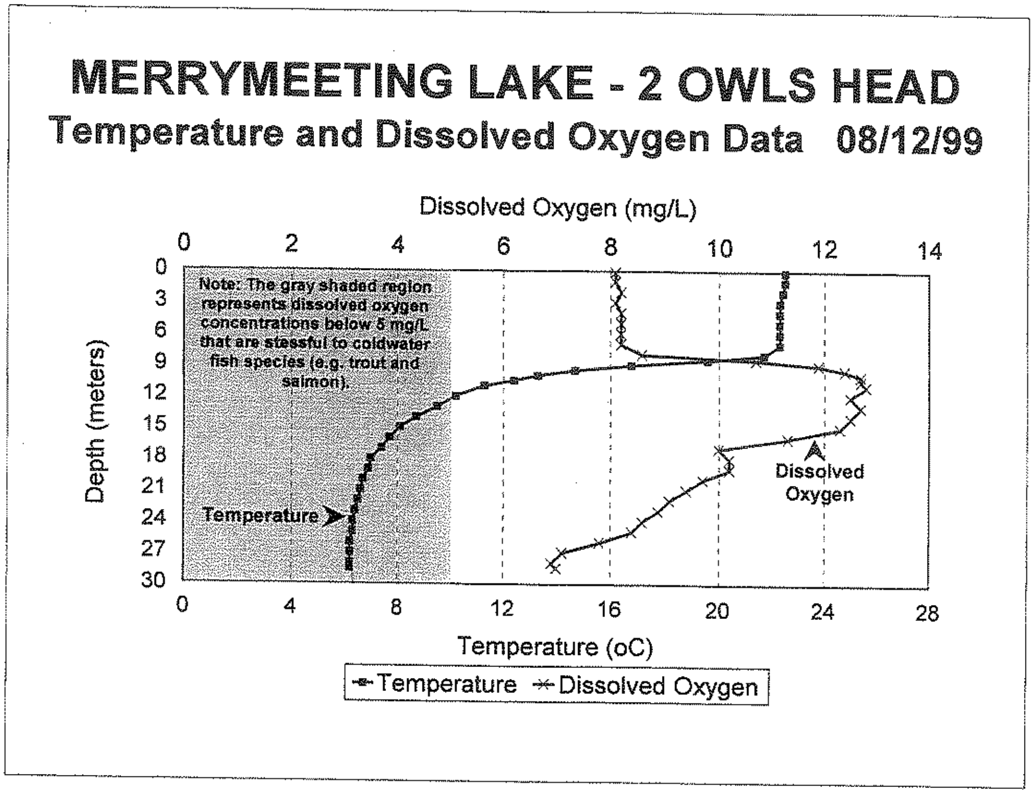

MERRYMEETING LAKE - 1 BROAD COVE
Temperature and Dissolved Oxygen Data 08/31/99
Dissolved Oxygen (mg/L)
0 3 6 9 12 15
Note: The gray shaded region represents dissolved oxygen concentrations below 5 mg/L that are stessful to coldwater fish species (e.g. trout and salmon).
Depth (meters)
0 3 6 9 12 15 18 21 24 27 30 33
Temperature
Dissolved Oxygen
0 6 12 18 24 30
Temperature (oC)
Temperature
Dissolved Oxygen

Figure 25. Temperature and dissolved profiles collected in Merrymeeting Lake, Site 2 Owls Head, on (A) August 12, 1999 and (B) August 31, 1999. The gray shaded region on the graph denotes dissolved oxygen concentrations stressful to coldwater fish. The temperature and dissolved oxygen data were collected at increments of no greater than one meter and are reported as degrees Centigrade (°C) and parts per million (ppm), respectively.


MERRYMEETING LAKE - 2 OWLS HEAD
Temperature and Dissolved Oxygen Data 08/12/99
Dissolved Oxygen (mg/L)
0 2 4 6 8 10 12 14
Depth (meters)
0 3 6 9 12 15 18 21 24 27 30
Note: The gray shaded region represents dissolved oxygen concentrations below 5 mg/L that are stessful to coldwater fish species (e.g. trout and salmon).
Temperature
Dissolved Oxygen
0 4 8 12 16 20 24 28
Temperature (oC)
Temperature Dissolved Oxygen

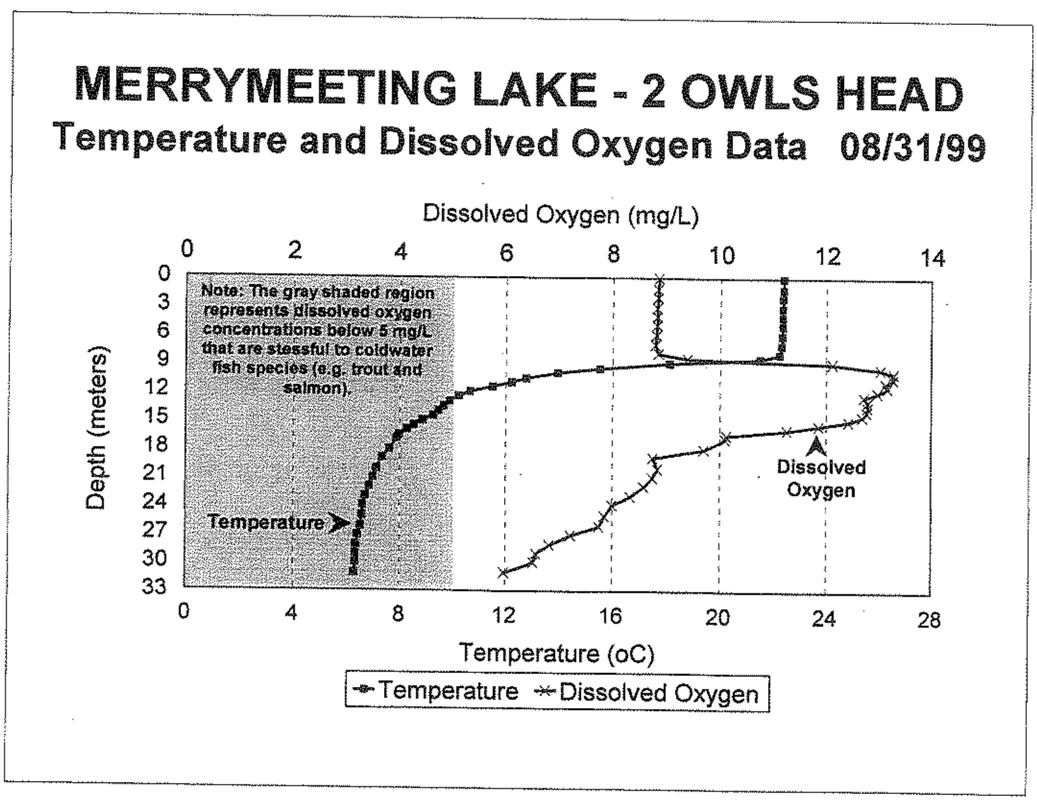
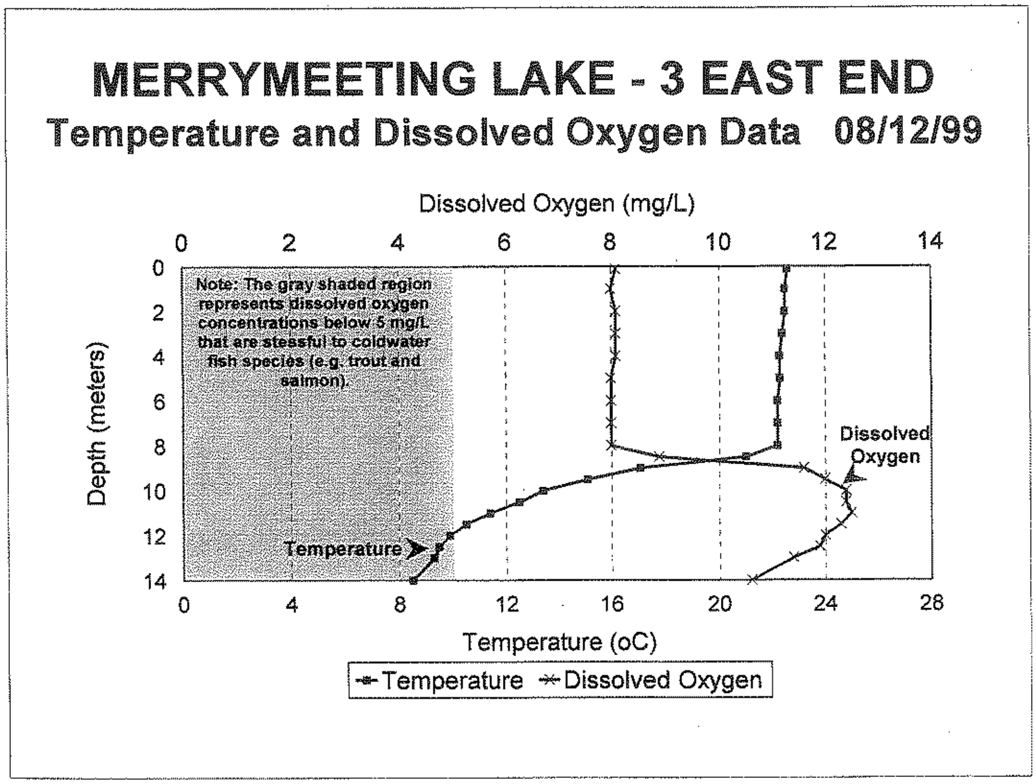
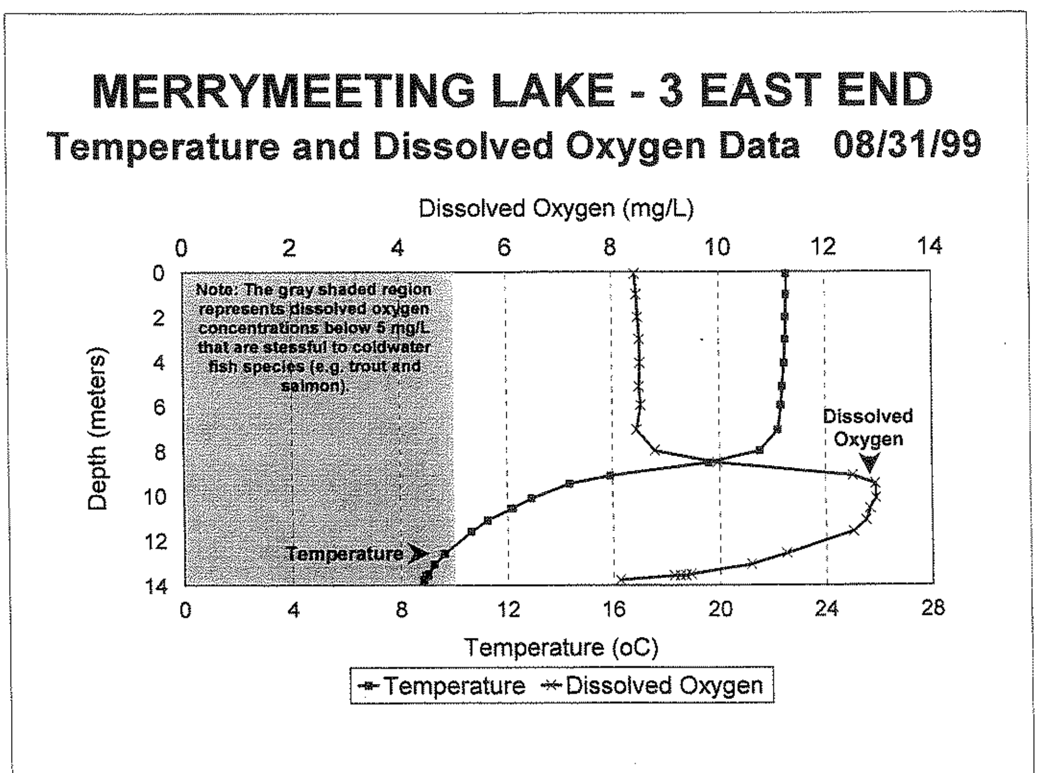

MERRYMEETING LAKE - 2 OWLS HEAD
Temperature and Dissolved Oxygen Data 08/31/99
Dissolved Oxygen (mg/L)
0 2 4 6 8 10 12 14
Depth (meters)
0 3 6 9 12 15 18 21 24 27 30 33
Note: The gray shaded region represents dissolved oxygen concentrations below 5 mg/L that are stessful to coldwater fish species (e.g. trout and salmon).
Temperature
Dissolved Oxygen
0 4 8 12 16 20 24 28
Temperature (oC)
Temperature Dissolved Oxygen

Figure 26. Temperature and dissolved profiles collected in Merrymeeting Lake, Site 3 East End, on (A) August 12, 1999 and (B) August 31, 1999. The gray shaded region on the graph denotes dissolved oxygen concentrations stressful to coldwater fish. The temperature and dissolved oxygen data were collected at increments of no greater than one meter and are reported as degrees Centigrade (°C) and parts per million (ppm), respectively.


MERRYMEETING LAKE - 3 EAST END
Temperature and Dissolved Oxygen Data 08/12/99
Dissolved Oxygen (mg/L)
0 2 4 6 8 10 12 14
Note: The gray shaded region represents dissolved oxygen concentrations below 5 mg/L that are stessful to coldwater fish species (e.g. trout and salmon).
Depth (meters)
0 2 4 6 8 10 12 14
Dissolved Oxygen
Temperature
0 4 8 12 16 20 24 28
Temperature (oC)
Temperature
Dissolved Oxygen


MERRYMEETING LAKE - 3 EAST END
Temperature and Dissolved Oxygen Data 08/31/99
Dissolved Oxygen (mg/L)
0 2 4 6 8 10 12 14
Note: The gray shaded region represents dissolved oxygen concentrations below 5 mg/L that are stessful to coldwater fish species (e.g. trout and salmon).
Depth (meters)
0 2 4 6 8 10 12 14
Dissolved Oxygen
Temperature
0 4 8 12 16 20 24 28
Temperature (oC)
Temperature
Dissolved Oxygen

APPENDIX A

Lakes Lay Monitoring Program, U.N.H.
[Lay Monitor Data]

Merrymeeting Lake, New Durham New Hampshire
-- subset of trophic indicators, all sites, 1999

1999 SUMMARY

Average transparency:	9.4	(1999:	74	values;	2.4	-	13.0	range)
Average chlorophyll:	1.6	(1999:	74	values;	0.4	-	2.7	range)
Average color:	6.3	(1999:	68	values;	2.3	-	10.7	range)
Average alk (gray):	7.3	(1999:	74	values;	6.1	-	8.2	range)
Average alk (pink):	7.7	(1999:	74	values;	6.5	-	8.5	range)
Total Phos. (ppb)	6.4	(1999:	9	values;	3.6	-	10.8	range)
SPCD (uS/cm)	41.1	(1999:	74	values;	39.5	-	42.2	range)

Site	Date	Trans-parency (meters)	Chl a (ppb)	Color (Pt-Co) units	Alkg (gray) @ pH 5.1 (mg/L)	Alkp (pink) @ pH 4.6 (mg/L)	pH (std units)	Total Phosphorus (ppb)	Specific Conductance @ 25°C (uS/cm)
1 BroadCv	5/6/99	9.8	1.4	8.9	6.1	6.5	-----	6.3	39.7
1 BroadCv	5/13/99	11.9	1.6	7.1	7.0	7.6	-----	-----	39.5
1 BroadCv	5/21/99	9.9	1.5	8.0	6.9	7.2	-----	-----	39.6
1 BroadCv	5/26/99	8.0	2.5	8.0	6.9	7.4	-----	-----	39.6
1 BroadCv	6/4/99	9.2	1.4	7.1	6.9	7.4	-----	-----	40.5
1 BroadCv	6/10/99	9.0	1.4	6.2	7.1	7.6	-----	-----	40.2
1 BroadCv	6/19/99	9.9	1.5	4.5	6.4	6.7	-----	-----	39.8
1 BroadCv	6/24/99	9.7	2.0	9.8	7.2	7.5	-----	-----	40.6
1 BroadCv	6/30/99	9.4	1.4	5.4	7.2	7.5	-----	-----	40.9
1 BroadCv	7/8/99	9.0	1.5	3.6	6.6	7.0	-----	4.2	41.0
1 BroadCv	7/12/99	9.9	1.6	7.1	7.4	7.6	-----	-----	41.2
1 BroadCv	7/19/99	12.3	1.1	8.5	7.5	7.8	7.3	-----	41.3
1 BroadCv	7/26/99	11.0	1.5	8.5	7.4	7.7	7.4	-----	41.4
1 BroadCv	8/5/99	12.0	1.0	9.4	7.5	7.8	7.5	-----	41.5
1 BroadCv	8/12/99	12.7	0.9	7.7	7.4	7.8	7.6	-----	41.3
1 BroadCv	8/16/99	13.0	1.1	6.8	7.3	7.7	7.6	-----	41.2
1 BroadCv	8/23/99	12.6	0.9	7.7	7.4	7.8	7.8	-----	41.8
1 BroadCv	8/31/99	11.9	0.9	2.6	7.6	7.8	7.6	-----	41.6
1 BroadCv	9/9/99	12.0	1.2	4.3	8.2	8.5	7.6	-----	41.7
1 BroadCv	9/14/99	11.4	1.1	3.4	7.9	8.2	7.6	-----	41.3
1 BroadCv	9/20/99	10.9	1.9	6.8	7.9	8.2	7.7	4.6	40.7
1 BroadCv	10/8/99	10.1	2.5	4.3	7.7	8.1	7.8	-----	40.1
1 BroadCv	10/27/99	9.0	1.7	2.3	7.6	7.9	7.4	-----	40.4
1 BroadCv	11/22/99	8.4	2.3	4.3	7.7	8.1	7.5	-----	40.0
2 Owls Hd	5/6/99	9.0	2.1	8.0	6.2	6.8	-----	10.8	40.1
2 Owls Hd	5/13/99	10.8	2.1	7.1	6.9	7.2	-----	-----	39.7

Site	Date	Trans-parency (meters)	Chl a (ppb)	Color (Pt-Co) units	Alkg (gray) @ pH 5.1 (mg/L)	Alkp (pink) @ pH 4.6 (mg/L)	pH (std units)	Total Phosphorus (ppb)	Specific Conductance @ 25°C (uS/cm)
2 Owls Hd	5/21/99	7.7	1.7	10.7	6.8	7.3	-----	-----	40.5
2 Owls Hd	5/26/99	7.9	1.7	6.2	6.9	7.3	-----	-----	40.3
2 Owls Hd	6/4/99	8.2	1.4	8.0	6.9	7.5	-----	-----	40.1
2 Owls Hd	6/10/99	8.0	2.1	7.1	7.1	7.6	-----	-----	40.8
2 Owls Hd	6/19/99	8.8	1.7	5.3	6.5	6.9	-----	-----	41.0
2 Owls Hd	6/24/99	9.2	2.3	8.0	6.6	7.2	-----	-----	41.5
2 Owls Hd	6/30/99	9.3	1.5	4.5	7.2	7.5	-----	-----	41.9
2 Owls Hd	7/8/99	8.0	1.6	-----	6.5	6.9	-----	7.6	41.6
2 Owls Hd	7/12/99	9.2	1.7	4.5	7.3	7.8	-----	-----	40.5
2 Owls Hd	7/19/99	9.9	1.4	8.0	7.4	7.8	7.2	-----	41.8
2 Owls Hd	7/26/99	9.9	1.7	8.9	7.2	7.6	7.4	-----	41.8
2 Owls Hd	8/5/99	10.7	1.1	6.0	7.5	7.9	7.4	-----	42.2
2 Owls Hd	8/12/99	10.5	1.2	7.7	7.4	7.7	7.5	-----	41.9
2 Owls Hd	8/16/99	11.5	1.2	7.7	7.3	7.6	7.6	-----	41.6
2 Owls Hd	8/23/99	11.6	1.1	6.0	7.5	8.1	7.5	-----	42.1
2 Owls Hd	8/31/99	11.7	0.8	3.4	7.4	7.7	7.5	-----	42.0
2 Owls Hd	9/9/99	10.4	1.4	4.3	8.1	8.2	7.5	-----	41.8
2 Owls Hd	9/14/99	9.3	1.5	4.3	7.9	8.2	7.5	-----	41.6
2 Owls Hd	9/20/99	9.0	2.2	3.4	7.7	8.2	7.6	3.6	41.1
2 Owls Hd	10/8/99	8.8	2.3	9.4	7.7	8.0	7.6	-----	40.6
2 Owls Hd	10/27/99	8.4	2.0	4.3	7.5	7.7	7.4	-----	41.2
2 Owls Hd	11/22/99	7.9	1.0	4.7	8.1	8.5	7.6	-----	41.4
3 EastEnd	5/6/99	8.3	2.4	-----	6.1	6.7	-----	8.9	40.6
3 EastEnd	5/13/99	10.2	1.9	-----	7.0	7.3	-----	-----	40.2
3 EastEnd	5/21/99	7.5	1.7	8.0	6.9	7.4	-----	-----	40.1
3 EastEnd	5/26/99	7.2	2.7	-----	6.9	7.3	-----	-----	40.4
3 EastEnd	6/4/99	8.2	2.1	6.2	7.0	7.4	-----	-----	40.5
3 EastEnd	6/10/99	7.4	2.0	6.2	7.1	7.5	-----	-----	40.2
3 EastEnd	6/19/99	8.7	2.1	4.5	6.3	6.7	-----	-----	40.8
3 EastEnd	6/24/99	8.1	1.1	6.2	7.3	7.5	-----	-----	40.8
3 EastEnd	6/30/99	7.9	1.8	4.5	7.4	7.8	-----	-----	41.7
3 EastEnd	7/8/99	8.0	1.6	6.2	6.4	6.8	-----	7.1	41.4
3 EastEnd	7/12/99	8.8	1.4	5.4	7.6	7.9	-----	-----	41.7
3 EastEnd	7/19/99	8.8	1.2	7.1	7.6	8.1	7.1	-----	41.9
3 EastEnd	7/26/99	9.2	1.5	3.6	7.3	7.7	7.3	-----	41.8
3 EastEnd	8/5/99	9.3	1.7	5.3	7.5	7.8	7.4	-----	42.1
3 EastEnd	8/12/99	10.0	1.3	-----	7.5	7.9	7.5	-----	41.9
3 EastEnd	8/16/99	11.3	0.4	8.0	7.5	7.9	7.6	-----	42.0
3 EastEnd	8/23/99	10.7	1.4	8.0	7.4	7.9	7.5	-----	41.1
3 EastEnd	8/31/99	10.0	1.2	4.5	7.5	7.8	7.5	-----	41.7
3 EastEnd	9/9/99	10.4	1.3	6.2	8.0	8.2	7.5	-----	41.5
3 EastEnd	9/14/99	9.1	1.3	7.1	7.8	8.2	7.6	-----	41.9
3 EastEnd	9/20/99	7.6	2.0	4.5	7.8	8.2	7.6	4.4	41.2
3 EastEnd	10/8/99	8.0	2.1	10.7	7.8	8.1	7.6	-----	41.1
3 EastEnd	10/27/99	8.4	1.7	4.5	7.4	7.7	7.5	-----	41.4

Site	Date	Trans-parency (meters)	Chl a (ppb)	Color (Pt-Co) units	Alkg (gray) @ pH 5.1 (mg/L)	Alkp (pink) @ pH 4.6 (mg/L)	pH (std units)	Total Phosphorus (ppb)	Specific Conductance @ 25^{o}C (uS/cm)
3 EastEnd	11/22/99	7.8	2.3	6.8	7.7	8.2	7.5	-----	41.7
Elly Cv	8/16/99	2.4	1.7	-----	7.4	7.7	7.5	-----	42.2
Elly Cv	9/20/99	2.5	1.6	3.4	7.9	8.1	7.5	-----	41.7

<< End of 1999 data listing; 74 records >>

Lakes Lay Monitoring Program, U.N.H.
[FBG Data – 08/12/99]

Site	Depth (meters)	Chlorophyll (ppb)	Dissolved Color (CPU)	Carbon Dioxide (mg/L)	Alkalinity gray end pt. @ pH 5.1	Alkalinity pink end pt. @ pH 4.6	Total Phosphorus (ppb)
Broad Cove	0-8.0	1.4	3.5		7.6	8.2	3.4
Broad Cove	0.5	1.1	4.4	1.0	7.6	8.1	-----
Broad Cove	19.0	2.3	6.1	2.4	7.5	8.0	6.3
Broad Cove	27.0	-----	-----	3.6	8.7	9.3	5.8
East End	0-8.0	1.9	5.2	-----	7.8	8.3	5.8
East End	0.5	1.7	5.2	1.0	7.6	8.2	-----
East End	11.0	5.2	9.6	1.0	7.4	7.9	4.5
East End	14.0	-----	-----	2.4	8.9	9.1	8.1
Owls Head	0-7.5	1.6	5.2	-----	7.7	8.3	5.8
Owls Head	0.5	1.6	4.4	1.0	7.5	8.0	-----
Owls Head	20.0	2.7	4.4	2.6	7.6	8.3	5.8
Owls Head	32.0	-----	-----	4.6	8.5	9.0	7.1

Site	Secchi Disk Transparency (meters)
1 Broad Cove	11.6 meters
2 Owls Head	10.4 meters
3 East End	10.4 meters

Lakes Lay Monitoring Program, U.N.H.
[FBG Data – 08/12/99]

Site	Depth (meters)	Temperature (oC)	Dissolved Oxygen (mg/L)	Specific Conductance (uS/cm)	Light (relative % surface)
1 Broad Cove	0.1	22.3	8.4	43.2	100.000
1 Broad Cove	0.5	-----	-----	-----	80.000
1 Broad Cove	1.0	22.3	8.4	43.2	64.000
1 Broad Cove	1.5	-----	-----	-----	-----
1 Broad Cove	2.0	22.2	8.4	43.2	50.000
1 Broad Cove	2.5	-----	-----	-----	-----
1 Broad Cove	3.0	22.2	8.4	43.2	27.000
1 Broad Cove	3.5	-----	-----	-----	-----
1 Broad Cove	4.0	22.2	8.4	43.1	25.000
1 Broad Cove	4.5	-----	-----	-----	-----
1 Broad Cove	5.0	22.2	8.4	43.1	24.000
1 Broad Cove	5.5	-----	-----	-----	-----
1 Broad Cove	6.0	22.2	8.3	43.1	19.000
1 Broad Cove	6.5	-----	-----	-----	-----
1 Broad Cove	7.0	22.2	8.4	43.1	18.000
1 Broad Cove	7.5	-----	-----	-----	-----
1 Broad Cove	8.0	22.1	8.3	43.1	16.000
1 Broad Cove	8.5	20.9	9.7	42.1	-----
1 Broad Cove	9.0	16.3	11.9	42.0	10.000
1 Broad Cove	9.5	14.1	12.6	42.0	-----
1 Broad Cove	10.0	12.6	12.6	42.5	8.000
1 Broad Cove	10.5	11.6	13.0	42.1	-----
1 Broad Cove	11.0	11.3	13.0	42.3	5.600
1 Broad Cove	11.5	10.8	12.9	42.2	-----
1 Broad Cove	12.0	10.5	12.8	42.3	4.100
1 Broad Cove	12.5	-----	-----	-----	-----
1 Broad Cove	13.0	9.8	12.7	42.3	3.200
1 Broad Cove	13.5	-----	-----	-----	-----
1 Broad Cove	14.0	9.2	13.0	42.3	2.400
1 Broad Cove	14.5	-----	-----	-----	-----
1 Broad Cove	15.0	8.6	12.8	-----	1.400
1 Broad Cove	15.5	-----	-----	-----	-----
1 Broad Cove	16.0	8.3	11.8	-----	1.100
1 Broad Cove	16.5	-----	-----	-----	-----
1 Broad Cove	17.0	7.8	11.4	-----	0.900
1 Broad Cove	17.5	-----	-----	-----	-----
1 Broad Cove	18.0	7.5	10.9	-----	0.660
1 Broad Cove	18.5	-----	-----	-----	-----
1 Broad Cove	19.0	7.2	10.5	-----	0.490
1 Broad Cove	19.5	-----	-----	-----	-----
1 Broad Cove	20.0	7.0	10.3	-----	0.380
1 Broad Cove	20.5	-----	-----	-----	-----

Site	Depth (meters)	Temperature (oC)	Dissolved Oxygen (mg/L)	Specific Conductance (uS/cm)	Light (relative % surface)
1 Broad Cove	21.0	6.8	9.9	-----	0.300
1 Broad Cove	21.5	-----	-----	-----	-----
1 Broad Cove	22.0	6.7	9.7	-----	0.190
1 Broad Cove	22.5	-----	-----	-----	-----
1 Broad Cove	23.0	6.6	9.3	-----	0.140
1 Broad Cove	23.5	-----	-----	-----	-----
1 Broad Cove	24.0	6.5	9.0	-----	0.110
1 Broad Cove	24.5	-----	-----	-----	-----
1 Broad Cove	25.0	6.4	8.8	-----	0.080
1 Broad Cove	25.5	-----	-----	-----	-----
1 Broad Cove	26.0	6.4	8.5	-----	-----
1 Broad Cove	26.5	-----	-----	-----	-----
1 Broad Cove	27.0	6.3	7.8	-----	-----
1 Broad Cove	27.5	-----	-----	-----	-----
1 Broad Cove	28.0	6.2	7.6	-----	-----
1 Broad Cove	28.5	-----	-----	-----	-----
1 Broad Cove	29.0	6.2	6.2	-----	-----
2 Owls Head	0.1	22.5	8.1	43.0	-----
2 Owls Head	0.5	-----	-----	43.0	-----
2 Owls Head	1.0	22.5	8.1	43.0	-----
2 Owls Head	1.5	-----	-----	-----	-----
2 Owls Head	2.0	22.4	8.2	43.0	-----
2 Owls Head	2.5	-----	-----	-----	-----
2 Owls Head	3.0	22.3	8.1	43.0	-----
2 Owls Head	3.5	-----	-----	-----	-----
2 Owls Head	4.0	22.3	8.2	43.0	-----
2 Owls Head	4.5	-----	-----	-----	-----
2 Owls Head	5.0	22.3	8.2	43.0	-----
2 Owls Head	5.5	-----	-----	-----	-----
2 Owls Head	6.0	22.3	8.2	43.0	-----
2 Owls Head	6.5	-----	-----	-----	-----
2 Owls Head	7.0	22.3	8.2	43.0	-----
2 Owls Head	7.5	-----	-----	-----	-----
2 Owls Head	8.0	21.7	8.6	43.0	-----
2 Owls Head	8.5	19.6	10.7	42.1	-----
2 Owls Head	9.0	16.8	11.9	41.6	-----
2 Owls Head	9.5	14.7	12.4	42.0	-----
2 Owls Head	10.0	13.3	12.7	41.9	-----
2 Owls Head	10.5	12.4	12.7	42.1	-----
2 Owls Head	11.0	11.3	12.8	42.1	-----
2 Owls Head	11.5	-----	-----	-----	-----
2 Owls Head	12.0	10.2	12.5	42.2	-----
2 Owls Head	12.5	-----	-----	-----	-----
2 Owls Head	13.0	9.5	12.7	42.2	-----
2 Owls Head	13.5	-----	-----	-----	-----
2 Owls Head	14.0	8.7	12.5	42.4	-----

Site	Depth (meters)	Temperature (oC)	Dissolved Oxygen (mg/L)	Specific Conductance (uS/cm)	Light (relative % surface)
2 Owls Head	14.5	-----	-----	-----	-----
2 Owls Head	15.0	8.1	12.3	-----	-----
2 Owls Head	15.5	-----	-----	-----	-----
2 Owls Head	16.0	7.7	11.3	-----	-----
2 Owls Head	16.5	-----	-----	-----	-----
2 Owls Head	17.0	7.4	10.0	-----	-----
2 Owls Head	17.5	-----	-----	-----	-----
2 Owls Head	18.0	7.0	10.2	-----	-----
2 Owls Head	18.5	-----	-----	-----	-----
2 Owls Head	19.0	6.9	10.2	-----	-----
2 Owls Head	19.5	-----	-----	-----	-----
2 Owls Head	20.0	6.7	9.7	-----	-----
2 Owls Head	20.5	-----	-----	-----	-----
2 Owls Head	21.0	6.6	9.4	-----	-----
2 Owls Head	21.5	-----	-----	-----	-----
2 Owls Head	22.0	6.5	9.1	-----	-----
2 Owls Head	22.5	-----	-----	-----	-----
2 Owls Head	23.0	6.4	8.9	-----	-----
2 Owls Head	23.5	-----	-----	-----	-----
2 Owls Head	24.0	6.3	8.6	-----	-----
2 Owls Head	24.5	-----	-----	-----	-----
2 Owls Head	25.0	6.3	8.4	-----	-----
2 Owls Head	25.5	-----	-----	-----	-----
2 Owls Head	26.0	6.2	7.8	-----	-----
2 Owls Head	26.5	-----	-----	-----	-----
2 Owls Head	27.0	6.2	7.1	-----	-----
2 Owls Head	27.5	-----	-----	-----	-----
2 Owls Head	28.0	6.2	6.9	-----	-----
2 Owls Head	28.5	6.2	7.0	-----	-----
3 East End	0.1	22.6	8.1	42.7	-----
3 East End	0.5	-----	-----	-----	-----
3 East End	1.0	22.5	8.0	43.1	-----
3 East End	1.5	-----	-----	-----	-----
3 East End	2.0	22.5	8.1	43.1	-----
3 East End	2.5	-----	-----	-----	-----
3 East End	3.0	22.4	8.1	43.1	-----
3 East End	3.5	-----	-----	-----	-----
3 East End	4.0	22.3	8.1	43.1	-----
3 East End	4.5	-----	-----	-----	-----
3 East End	5.0	22.3	8.0	43.1	-----
3 East End	5.5	-----	-----	-----	-----
3 East End	6.0	22.2	8.0	43.1	-----
3 East End	6.5	-----	-----	-----	-----
3 East End	7.0	22.2	8.0	43.1	-----
3 East End	7.5	-----	-----	-----	-----
3 East End	8.0	22.2	8.0	43.0	-----

Site	Depth (meters)	Temperature (oC)	Dissolved Oxygen (mg/L)	Specific Conductance (uS/cm)	Light (relative % surface)
3 East End	8.5	21.0	8.9	43.1	-----
3 East End	9.0	17.1	11.6	41.9	-----
3 East End	9.5	15.1	12.0	41.8	-----
3 East End	10.0	13.4	12.4	41.9	-----
3 East End	10.5	12.5	12.4	42.0	-----
3 East End	11.0	11.4	12.5	42.1	-----
3 East End	11.5	10.5	12.3	-----	-----
3 East End	12.0	9.9	12.0	42.2	-----
3 East End	12.5	9.5	11.9	-----	-----
3 East End	13.0	9.3	11.4	42.4	-----
3 East End	13.5	-----	-----	-----	-----
3 East End	14.0	8.5	10.6	42.5	-----

Lakes Lay Monitoring Program, U.N.H.
[FBG Data – 08/31/99]

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
1 Broad Cove	0.01	22.4	8.9	102.1	38.0	7.3	207	0.8
1 Broad Cove	0.02	22.4	8.9	102.1	38.0	7.3	207	0.8
1 Broad Cove	0.17	22.4	8.9	102.0	38.0	7.3	207	0.8
1 Broad Cove	0.56	22.4	8.9	102.1	38.0	7.3	207	0.7
1 Broad Cove	0.87	22.4	8.9	102.0	38.0	7.3	206	0.7
1 Broad Cove	1.16	22.4	8.9	101.9	38.0	7.3	207	0.7
1 Broad Cove	1.56	22.3	8.9	101.9	38.0	7.3	207	0.7
1 Broad Cove	1.83	22.3	8.9	101.9	38.0	7.3	207	0.7
1 Broad Cove	2.09	22.3	8.9	101.9	38.0	7.3	207	0.7
1 Broad Cove	2.39	22.3	8.8	101.8	38.0	7.3	207	0.7
1 Broad Cove	2.70	22.3	8.8	101.8	38.0	7.3	207	0.7
1 Broad Cove	2.93	22.3	8.8	101.8	38.0	7.3	207	0.7
1 Broad Cove	3.15	22.3	8.8	101.6	38.0	7.3	207	0.7
1 Broad Cove	3.39	22.3	8.8	101.6	38.0	7.3	207	0.7
1 Broad Cove	3.62	22.3	8.8	101.7	38.0	7.3	208	0.6
1 Broad Cove	3.89	22.3	8.8	101.7	38.0	7.3	208	0.7
1 Broad Cove	4.08	22.3	8.8	101.8	38.0	7.4	208	0.7
1 Broad Cove	4.27	22.3	8.8	101.7	38.0	7.4	208	0.6
1 Broad Cove	4.43	22.3	8.8	101.6	38.0	7.4	208	0.6
1 Broad Cove	4.61	22.3	8.8	101.4	38.0	7.4	208	0.6
1 Broad Cove	4.80	22.3	8.8	101.6	38.0	7.4	208	0.6
1 Broad Cove	4.98	22.3	8.8	101.6	38.0	7.4	208	0.6
1 Broad Cove	5.18	22.3	8.8	101.6	38.0	7.4	208	0.6
1 Broad Cove	5.44	22.3	8.8	101.6	38.0	7.4	208	0.6
1 Broad Cove	5.67	22.3	8.8	101.6	38.0	7.4	208	0.6
1 Broad Cove	5.82	22.3	8.8	101.5	38.0	7.4	208	0.6
1 Broad Cove	5.92	22.3	8.8	101.5	38.0	7.4	208	0.6

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
1 Broad Cove	6.03	22.3	8.8	101.4	38.0	7.4	208	0.6
1 Broad Cove	6.15	22.3	8.8	101.5	38.0	7.4	208	0.6
1 Broad Cove	6.26	22.3	8.8	101.4	38.0	7.4	208	0.6
1 Broad Cove	6.39	22.3	8.8	101.3	38.0	7.4	209	0.6
1 Broad Cove	6.51	22.3	8.8	101.4	38.0	7.4	209	0.6
1 Broad Cove	6.60	22.3	8.8	101.4	38.0	7.4	209	0.6
1 Broad Cove	6.72	22.3	8.8	101.3	38.0	7.4	209	0.6
1 Broad Cove	6.83	22.3	8.8	101.3	38.0	7.4	209	0.6
1 Broad Cove	6.94	22.3	8.8	101.2	38.0	7.4	209	0.6
1 Broad Cove	7.04	22.3	8.8	101.2	38.0	7.4	209	0.6
1 Broad Cove	7.12	22.3	8.8	101.4	38.0	7.4	209	0.6
1 Broad Cove	7.24	22.3	8.8	101.5	38.0	7.4	209	0.6
1 Broad Cove	7.35	22.3	8.8	101.6	38.0	7.4	209	0.6
1 Broad Cove	7.45	22.3	8.8	101.5	38.0	7.4	210	0.6
1 Broad Cove	7.59	22.3	8.8	101.5	38.0	7.4	210	0.6
1 Broad Cove	7.73	22.3	8.8	101.6	38.0	7.4	210	0.6
1 Broad Cove	7.87	22.2	8.9	101.7	38.0	7.4	210	0.6
1 Broad Cove	7.99	22.2	8.9	101.8	38.0	7.4	210	0.6
1 Broad Cove	8.13	22.1	8.9	101.9	38.0	7.4	210	0.6
1 Broad Cove	8.30	21.9	9.0	102.3	38.0	7.4	211	0.6
1 Broad Cove	8.49	21.5	9.4	106.5	38.0	7.4	211	0.6
1 Broad Cove	8.64	20.7	9.9	110.8	37.0	7.4	211	0.6
1 Broad Cove	8.78	19.9	10.5	115.6	37.0	7.4	211	0.6
1 Broad Cove	8.89	19.2	11.1	119.9	37.0	7.4	211	0.7
1 Broad Cove	8.97	18.6	11.7	125.5	37.0	7.4	211	0.7
1 Broad Cove	9.01	18.1	12.1	128.4	37.0	7.4	211	0.8
1 Broad Cove	9.06	17.8	12.4	130.1	37.0	7.4	210	0.8
1 Broad Cove	9.12	17.5	12.4	130.1	37.0	7.4	210	0.7
1 Broad Cove	9.20	17.2	12.6	131.0	37.0	7.4	210	0.8
1 Broad Cove	9.26	16.8	12.8	131.7	37.0	7.4	210	0.8

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
1 Broad Cove	9.35	16.5	12.9	131.9	37.0	7.5	210	0.8
1 Broad Cove	9.46	16.0	13.0	132.2	37.0	7.5	209	0.7
1 Broad Cove	9.57	15.5	13.0	130.7	37.0	7.5	210	0.7
1 Broad Cove	9.65	15.1	13.2	130.6	37.0	7.5	210	0.7
1 Broad Cove	9.72	14.7	13.2	130.3	37.0	7.5	210	0.8
1 Broad Cove	9.87	14.3	13.3	130.4	37.0	7.5	210	0.7
1 Broad Cove	10.02	14.0	13.3	128.8	36.0	7.5	210	0.8
1 Broad Cove	10.14	13.6	13.3	128.1	36.0	7.5	210	0.8
1 Broad Cove	10.23	13.3	13.4	128.0	36.0	7.5	211	0.8
1 Broad Cove	10.32	13.2	13.4	127.4	36.0	7.5	211	0.8
1 Broad Cove	10.39	13.0	13.3	126.3	37.0	7.5	211	0.8
1 Broad Cove	10.49	12.9	13.3	125.7	36.0	7.5	212	0.8
1 Broad Cove	10.60	12.8	13.3	125.4	36.0	7.5	212	0.8
1 Broad Cove	10.67	12.7	13.2	124.8	36.0	7.5	213	0.8
1 Broad Cove	10.75	12.6	13.2	123.9	36.0	7.5	214	0.8
1 Broad Cove	10.83	12.5	13.1	123.2	36.0	7.5	214	0.8
1 Broad Cove	10.91	12.4	13.1	123.0	36.0	7.5	215	0.8
1 Broad Cove	11.01	12.2	13.1	122.4	36.0	7.5	215	0.9
1 Broad Cove	11.10	12.1	13.1	121.7	36.0	7.5	215	0.9
1 Broad Cove	11.24	11.9	13.1	121.5	36.0	7.5	216	0.9
1 Broad Cove	11.37	11.7	13.2	121.2	36.0	7.5	217	0.8
1 Broad Cove	11.49	11.5	13.2	120.8	36.0	7.5	217	0.8
1 Broad Cove	11.62	11.4	13.1	119.3	36.0	7.5	219	0.8
1 Broad Cove	11.74	11.1	13.0	118.3	36.0	7.5	219	0.8
1 Broad Cove	11.83	10.9	13.1	118.2	36.0	7.5	220	0.8
1 Broad Cove	11.93	10.8	13.1	117.9	36.0	7.5	221	0.8
1 Broad Cove	12.02	10.7	13.0	116.7	36.0	7.5	222	0.8
1 Broad Cove	12.08	10.6	13.0	116.2	36.0	7.5	222	0.8
1 Broad Cove	12.12	10.5	12.9	115.7	36.0	7.5	222	0.8
1 Broad Cove	12.17	10.4	12.9	115.5	36.0	7.5	223	0.8

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
1 Broad Cove	12.21	10.4	12.9	115.3	36.0	7.5	223	0.9
1 Broad Cove	12.27	10.4	12.9	115.0	36.0	7.5	223	0.9
1 Broad Cove	12.35	10.3	12.9	114.7	36.0	7.5	224	0.9
1 Broad Cove	12.42	10.3	12.8	114.3	36.0	7.5	224	0.9
1 Broad Cove	12.49	10.2	12.7	113.3	36.0	7.4	225	0.9
1 Broad Cove	12.55	10.2	12.7	113.1	36.0	7.4	225	0.9
1 Broad Cove	12.61	10.1	12.7	113.1	36.0	7.4	225	0.9
1 Broad Cove	12.65	10.1	12.7	113.1	36.0	7.4	225	0.9
1 Broad Cove	12.73	10.1	12.8	113.2	36.0	7.4	225	1.1
1 Broad Cove	12.83	10.0	12.8	113.0	36.0	7.4	225	1.1
1 Broad Cove	12.91	9.9	12.8	113.0	36.0	7.4	226	1.1
1 Broad Cove	13.01	9.9	12.8	113.0	36.0	7.4	225	1.1
1 Broad Cove	13.09	9.8	12.8	113.1	36.0	7.4	225	1.1
1 Broad Cove	13.16	9.8	12.8	112.9	36.0	7.4	225	1.1
1 Broad Cove	13.22	9.8	12.8	112.9	36.0	7.4	226	1.1
1 Broad Cove	13.28	9.7	12.8	112.8	36.0	7.4	226	1.2
1 Broad Cove	13.37	9.7	12.8	112.5	36.0	7.4	226	1.2
1 Broad Cove	13.53	9.7	12.8	112.4	36.0	7.4	226	1.2
1 Broad Cove	13.67	9.6	12.8	112.4	36.0	7.4	226	1.4
1 Broad Cove	13.80	9.6	12.8	112.1	36.0	7.4	226	1.5
1 Broad Cove	13.90	9.5	12.8	111.9	36.0	7.4	227	1.4
1 Broad Cove	14.01	9.5	12.8	111.7	36.0	7.4	227	1.4
1 Broad Cove	14.20	9.4	12.8	111.5	36.0	7.4	227	1.4
1 Broad Cove	14.39	9.3	12.8	111.4	36.0	7.4	228	1.4
1 Broad Cove	14.52	9.3	12.7	110.5	36.0	7.4	228	1.4
1 Broad Cove	14.67	9.2	12.7	110.0	36.0	7.4	229	1.4
1 Broad Cove	14.79	9.1	12.6	109.3	36.0	7.4	230	1.5
1 Broad Cove	14.89	9.0	12.6	108.6	36.0	7.4	231	1.5
1 Broad Cove	15.03	8.9	12.4	107.2	36.0	7.4	232	1.5
1 Broad Cove	15.17	8.8	12.4	106.4	36.0	7.4	233	1.6

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
1 Broad Cove	15.33	8.7	12.3	105.2	36.0	7.4	234	1.6
1 Broad Cove	15.44	8.6	12.1	104.0	36.0	7.3	236	1.6
1 Broad Cove	15.53	8.5	11.9	101.5	36.0	7.3	237	1.5
1 Broad Cove	15.65	8.5	11.7	100.2	37.0	7.3	238	1.6
1 Broad Cove	15.79	8.4	11.6	99.1	36.0	7.3	239	1.7
1 Broad Cove	15.89	8.4	11.5	97.8	37.0	7.3	240	1.9
1 Broad Cove	16.00	8.3	11.3	95.7	37.0	7.3	241	1.9
1 Broad Cove	16.06	8.2	11.0	93.4	37.0	7.3	243	1.9
1 Broad Cove	16.20	8.2	10.7	91.0	37.0	7.2	245	2.0
1 Broad Cove	16.26	8.1	10.5	89.0	37.0	7.2	246	1.9
1 Broad Cove	16.34	8.1	10.1	85.5	37.0	7.2	247	1.9
1 Broad Cove	16.40	8.1	10.1	85.3	37.0	7.2	247	1.8
1 Broad Cove	16.47	8.0	10.1	85.4	37.0	7.2	248	1.9
1 Broad Cove	16.56	8.0	10.1	85.4	37.0	7.2	248	1.8
1 Broad Cove	16.65	8.0	10.2	85.9	37.0	7.1	248	2.0
1 Broad Cove	16.76	7.9	10.2	85.7	37.0	7.1	248	2.1
1 Broad Cove	16.95	7.9	10.1	85.0	37.0	7.1	249	2.1
1 Broad Cove	17.11	7.9	10.0	83.7	37.0	7.1	250	2.1
1 Broad Cove	17.33	7.8	9.6	80.4	37.0	7.1	251	2.3
1 Broad Cove	17.48	7.8	9.5	79.9	37.0	7.1	251	2.3
1 Broad Cove	17.74	7.7	9.6	80.4	37.0	7.0	251	2.3
1 Broad Cove	17.93	7.7	9.7	80.8	37.0	7.0	251	2.3
1 Broad Cove	18.05	7.6	9.7	81.2	37.0	7.0	251	2.3
1 Broad Cove	18.14	7.6	9.7	80.7	37.0	7.0	251	2.5
1 Broad Cove	18.23	7.6	9.5	79.6	37.0	7.0	252	2.4
1 Broad Cove	18.37	7.5	9.4	78.5	37.0	7.0	253	2.4
1 Broad Cove	18.48	7.5	9.0	75.3	37.0	6.9	253	2.4
1 Broad Cove	18.61	7.4	8.9	74.1	37.0	6.9	254	2.5
1 Broad Cove	18.81	7.4	8.8	73.3	37.0	6.9	254	2.4
1 Broad Cove	18.96	7.4	8.8	72.8	37.0	6.9	255	2.4

Site	Depth	Temperature	Dissolved Oxygen	Dissolved Oxygen	Specific Conductivity @ 25°C	pH	Oxidation Reduction Potential	Turbidity
	(meters)	(°C)	(mg/L)	(% saturation)	(uS/cm)			(NTU)
1 Broad Cove	19.15	7.3	8.7	71.9	37.0	6.9	255	2.4
1 Broad Cove	19.34	7.3	8.7	72.1	37.0	6.8	255	2.4
1 Broad Cove	19.50	7.2	8.7	72.4	37.0	6.8	255	2.4
1 Broad Cove	19.65	7.2	8.8	72.7	37.0	6.8	255	2.4
1 Broad Cove	19.87	7.2	8.8	73.1	37.0	6.8	255	2.4
1 Broad Cove	20.14	7.1	8.9	73.1	37.0	6.8	255	2.5
1 Broad Cove	20.50	7.1	8.9	73.1	37.0	6.8	256	2.5
1 Broad Cove	20.80	7.1	8.8	72.5	37.0	6.8	256	2.5
1 Broad Cove	21.07	7.0	8.8	72.1	37.0	6.7	256	2.6
1 Broad Cove	21.31	7.0	8.8	72.0	37.0	6.7	256	2.8
1 Broad Cove	21.55	6.9	8.8	71.9	37.0	6.7	256	2.7
1 Broad Cove	21.76	6.9	8.7	71.6	37.0	6.7	256	2.6
1 Broad Cove	22.00	6.9	8.6	70.5	37.0	6.7	257	2.6
1 Broad Cove	22.26	6.8	8.6	70.2	37.0	6.7	257	2.6
1 Broad Cove	22.54	6.8	8.5	69.8	37.0	6.7	257	2.6
1 Broad Cove	22.77	6.7	8.5	69.4	37.0	6.7	257	2.6
1 Broad Cove	23.02	6.7	8.3	68.2	37.0	6.6	258	2.7
1 Broad Cove	23.28	6.7	8.3	67.5	37.0	6.6	258	2.7
1 Broad Cove	23.47	6.7	8.2	66.9	37.0	6.6	258	2.7
1 Broad Cove	23.71	6.6	8.1	66.2	37.0	6.6	259	2.7
1 Broad Cove	23.97	6.6	8.0	65.2	37.0	6.6	259	2.7
1 Broad Cove	24.19	6.6	7.9	64.7	37.0	6.6	259	2.8
1 Broad Cove	24.43	6.6	7.9	64.3	37.0	6.6	259	2.7
1 Broad Cove	24.72	6.6	7.9	64.1	37.0	6.5	259	2.8
1 Broad Cove	25.06	6.6	7.9	64.0	37.0	6.5	259	2.8
1 Broad Cove	25.42	6.6	7.8	63.8	37.0	6.5	260	2.8
1 Broad Cove	25.85	6.5	7.8	63.5	37.0	6.5	260	2.8
1 Broad Cove	26.19	6.5	7.8	63.1	37.0	6.5	261	2.8
1 Broad Cove	26.50	6.5	7.6	61.4	38.0	6.5	262	2.9
1 Broad Cove	26.89	6.5	7.4	59.8	38.0	6.5	262	2.9

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
1 Broad Cove	27.13	6.4	7.2	58.7	38.0	6.5	263	3.1
1 Broad Cove	27.31	6.4	7.1	57.9	38.0	6.4	263	3.2
1 Broad Cove	27.43	6.4	7.0	56.8	38.0	6.4	263	3.3
1 Broad Cove	27.62	6.4	6.9	56.3	38.0	6.4	263	3.5
1 Broad Cove	27.88	6.4	6.9	55.9	38.0	6.4	264	3.5
1 Broad Cove	28.13	6.4	6.8	55.4	38.0	6.4	264	3.5
1 Broad Cove	28.29	6.4	6.7	54.3	38.0	6.4	264	3.5
1 Broad Cove	28.46	6.4	6.7	53.9	38.0	6.4	264	3.5
1 Broad Cove	28.71	6.4	6.6	53.6	38.0	6.4	264	3.5
1 Broad Cove	28.92	6.3	6.6	53.5	38.0	6.4	264	3.7
1 Broad Cove	29.09	6.3	6.6	53.3	38.0	6.4	264	3.8
1 Broad Cove	29.27	6.3	6.6	53.2	38.0	6.4	264	3.9
1 Broad Cove	29.48	6.3	6.6	53.2	38.0	6.4	265	4.0
1 Broad Cove	29.74	6.3	6.6	53.2	38.0	6.3	265	4.0
1 Broad Cove	30.01	6.3	6.5	52.9	38.0	6.3	265	4.1
1 Broad Cove	30.25	6.3	6.4	52.1	38.0	6.3	265	4.1
1 Broad Cove	30.43	6.3	6.3	51.3	38.0	6.3	266	4.2
1 Broad Cove	30.63	6.3	6.3	50.7	38.0	6.3	266	4.7
1 Broad Cove	30.81	6.3	6.1	49.5	38.0	6.3	266	4.6
1 Broad Cove	31.10	6.3	6.0	48.4	39.0	6.3	267	4.8
2 Owls Head	0.07	22.4	8.5	98.2	38.0	7.3	201	1.4
2 Owls Head	0.12	22.4	8.5	98.1	38.0	7.3	201	1.4
2 Owls Head	0.28	22.4	8.5	98.1	38.0	7.3	201	1.4
2 Owls Head	0.48	22.4	8.5	98.3	38.0	7.3	201	1.4
2 Owls Head	0.78	22.4	8.5	98.3	38.0	7.3	201	1.4
2 Owls Head	1.03	22.4	8.5	98.2	38.0	7.3	201	1.3
2 Owls Head	1.29	22.4	8.5	98.1	38.0	7.3	201	1.3
2 Owls Head	1.58	22.4	8.5	98.0	38.0	7.3	201	1.3
2 Owls Head	1.90	22.4	8.5	97.9	38.0	7.3	201	1.2
2 Owls Head	2.28	22.4	8.5	98.1	38.0	7.3	201	1.2

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
2 Owls Head	2.62	22.4	8.5	98.0	38.0	7.3	201	1.3
2 Owls Head	2.88	22.4	8.5	98.1	38.0	7.3	201	1.3
2 Owls Head	3.12	22.4	8.5	98.0	38.0	7.3	201	1.4
2 Owls Head	3.35	22.4	8.5	98.0	38.0	7.3	201	1.4
2 Owls Head	3.57	22.4	8.5	97.9	38.0	7.3	201	1.4
2 Owls Head	3.77	22.4	8.5	97.9	38.0	7.3	201	1.4
2 Owls Head	3.96	22.4	8.5	97.9	38.0	7.3	201	1.5
2 Owls Head	4.20	22.4	8.5	97.9	38.0	7.3	201	1.5
2 Owls Head	4.41	22.4	8.5	97.9	38.0	7.3	201	1.5
2 Owls Head	4.67	22.4	8.5	98.0	38.0	7.3	201	1.6
2 Owls Head	4.94	22.4	8.5	98.0	38.0	7.3	201	1.6
2 Owls Head	5.18	22.4	8.5	98.1	38.0	7.3	201	1.6
2 Owls Head	5.40	22.4	8.5	98.1	38.0	7.3	201	1.6
2 Owls Head	5.60	22.4	8.5	98.1	38.0	7.3	201	1.5
2 Owls Head	5.80	22.4	8.5	98.1	38.0	7.3	201	1.5
2 Owls Head	6.01	22.4	8.5	98.0	38.0	7.3	201	1.5
2 Owls Head	6.19	22.4	8.5	98.0	38.0	7.3	201	1.5
2 Owls Head	6.39	22.4	8.5	98.0	38.0	7.3	201	1.5
2 Owls Head	6.76	22.4	8.5	97.9	38.0	7.3	201	1.5
2 Owls Head	7.20	22.3	8.5	97.8	38.0	7.3	201	1.5
2 Owls Head	7.60	22.3	8.5	97.7	38.0	7.3	202	1.6
2 Owls Head	7.91	22.2	8.5	97.6	38.0	7.3	202	1.6
2 Owls Head	8.22	22.1	8.5	97.4	38.0	7.3	203	1.5
2 Owls Head	8.47	21.8	8.9	100.8	38.0	7.3	202	1.5
2 Owls Head	8.85	21.2	9.1	102.9	36.0	7.3	203	1.5
2 Owls Head	9.16	18.8	10.2	109.4	36.0	7.4	202	1.6
2 Owls Head	9.45	17.3	11.4	119.0	36.0	7.4	202	1.6
2 Owls Head	9.79	15.8	12.5	125.6	36.0	7.4	202	1.6
2 Owls Head	10.12	14.8	12.9	127.6	36.0	7.4	202	1.6
2 Owls Head	10.43	13.6	13.3	128.1	36.0	7.4	202	1.6

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
2 Owls Head	10.82	12.6	13.5	127.4	36.0	7.4	204	1.7
2 Owls Head	11.15	12.3	13.3	124.1	36.0	7.4	205	1.7
2 Owls Head	11.39	11.9	13.3	123.3	36.0	7.4	207	1.8
2 Owls Head	11.70	11.5	13.3	122.3	36.0	7.4	207	1.9
2 Owls Head	12.00	11.1	13.2	120.4	36.0	7.4	208	1.9
2 Owls Head	12.27	10.7	13.1	117.8	36.0	7.4	210	1.9
2 Owls Head	12.53	10.3	13.0	115.9	36.0	7.4	211	1.9
2 Owls Head	12.74	10.1	13.0	114.9	36.0	7.4	212	1.8
2 Owls Head	12.99	9.9	12.9	113.9	36.0	7.4	213	1.9
2 Owls Head	13.22	9.7	12.7	111.5	36.0	7.4	214	1.8
2 Owls Head	13.44	9.5	12.7	110.7	36.0	7.4	215	1.9
2 Owls Head	13.68	9.3	12.6	109.7	36.0	7.4	216	1.9
2 Owls Head	13.92	9.2	12.5	108.3	36.0	7.4	217	1.9
2 Owls Head	14.15	9.0	12.2	105.6	36.0	7.4	219	1.8
2 Owls Head	14.44	8.8	12.2	104.8	36.0	7.4	220	1.8
2 Owls Head	14.70	8.7	12.0	103.3	36.0	7.3	222	1.8
2 Owls Head	14.92	8.5	11.8	101.3	36.0	7.3	224	1.8
2 Owls Head	15.08	8.4	11.3	96.2	36.0	7.3	226	1.9
2 Owls Head	15.24	8.3	11.1	94.3	36.0	7.3	227	1.9
2 Owls Head	15.43	8.2	10.9	92.5	36.0	7.3	229	1.9
2 Owls Head	15.62	8.0	10.7	90.5	36.0	7.3	231	1.9
2 Owls Head	15.75	7.9	10.3	87.0	36.0	7.2	232	1.9
2 Owls Head	15.95	7.9	10.2	85.8	36.0	7.2	233	1.9
2 Owls Head	16.16	7.8	10.1	84.8	36.0	7.2	234	1.9
2 Owls Head	16.36	7.7	10.0	83.9	36.0	7.2	235	1.9
2 Owls Head	16.56	7.6	9.9	82.6	37.0	7.2	236	1.9
2 Owls Head	16.77	7.6	9.8	82.0	37.0	7.1	236	2.1
2 Owls Head	16.89	7.5	9.7	80.9	37.0	7.1	237	2.0
2 Owls Head	17.07	7.4	9.6	79.8	37.0	7.1	238	2.0
2 Owls Head	17.24	7.3	9.4	78.0	37.0	7.1	238	2.1

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
2 Owls Head	17.42	7.3	9.3	77.4	37.0	7.1	239	2.1
2 Owls Head	17.58	7.2	9.3	77.0	37.0	7.0	239	2.1
2 Owls Head	17.75	7.2	9.3	76.8	37.0	7.0	240	2.1
2 Owls Head	17.91	7.1	9.2	76.3	37.0	7.0	240	2.1
2 Owls Head	18.06	7.1	9.2	76.1	37.0	7.0	240	2.1
2 Owls Head	18.28	7.1	9.2	75.8	37.0	7.0	241	2.1
2 Owls Head	18.47	7.0	9.1	75.1	37.0	7.0	241	2.1
2 Owls Head	18.65	7.0	9.0	74.4	37.0	6.9	241	2.2
2 Owls Head	18.82	7.0	9.0	74.0	37.0	6.9	242	2.4
2 Owls Head	18.97	6.9	8.9	73.5	37.0	6.9	242	2.4
2 Owls Head	19.12	6.9	8.9	72.9	37.0	6.9	242	2.3
2 Owls Head	19.29	6.9	8.8	72.1	37.0	6.9	242	2.3
2 Owls Head	19.50	6.9	8.8	71.9	37.0	6.9	243	2.3
2 Owls Head	19.74	6.8	8.7	71.7	37.0	6.8	243	2.4
2 Owls Head	19.99	6.8	8.7	71.3	37.0	6.8	244	2.4
2 Owls Head	20.27	6.8	8.6	70.1	37.0	6.8	244	2.4
2 Owls Head	20.65	6.7	8.5	69.6	37.0	6.8	245	2.4
2 Owls Head	21.06	6.7	8.5	69.0	37.0	6.8	245	2.5
2 Owls Head	21.45	6.6	8.4	68.3	37.0	6.8	245	2.5
2 Owls Head	21.80	6.6	8.2	66.7	37.0	6.7	246	2.6
2 Owls Head	22.12	6.6	8.1	66.1	37.0	6.7	246	2.6
2 Owls Head	22.41	6.6	8.1	65.6	37.0	6.7	246	2.6
2 Owls Head	22.66	6.6	8.0	65.1	37.0	6.7	247	2.7
2 Owls Head	22.91	6.5	7.8	63.8	37.0	6.7	247	2.7
2 Owls Head	23.22	6.5	7.8	63.2	37.0	6.7	247	2.8
2 Owls Head	23.45	6.5	7.7	62.6	37.0	6.6	248	2.8
2 Owls Head	23.62	6.5	7.6	62.1	37.0	6.6	248	2.9
2 Owls Head	23.80	6.5	7.5	61.2	37.0	6.6	248	2.9
2 Owls Head	23.97	6.5	7.5	60.7	37.0	6.6	249	2.9
2 Owls Head	24.14	6.5	7.4	60.3	37.0	6.6	249	2.9

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
2 Owls Head	24.29	6.5	7.4	59.9	37.0	6.6	249	2.9
2 Owls Head	24.45	6.5	7.3	59.3	37.0	6.6	249	3.0
2 Owls Head	24.71	6.4	7.3	59.0	37.0	6.6	250	3.0
2 Owls Head	25.00	6.4	7.2	58.6	37.0	6.5	250	3.1
2 Owls Head	25.23	6.4	7.2	58.0	37.0	6.5	250	3.1
2 Owls Head	25.40	6.4	7.0	57.0	37.0	6.5	251	3.1
2 Owls Head	25.72	6.4	7.0	56.3	38.0	6.5	251	3.2
2 Owls Head	26.02	6.4	6.9	55.6	38.0	6.5	252	3.3
2 Owls Head	26.22	6.3	6.7	54.2	38.0	6.5	253	3.3
2 Owls Head	26.39	6.3	6.3	51.3	38.0	6.5	253	3.4
2 Owls Head	26.70	6.3	6.2	50.3	38.0	6.4	253	3.5
2 Owls Head	26.96	6.3	6.1	49.5	38.0	6.4	253	3.6
2 Owls Head	27.14	6.3	6.0	48.8	38.0	6.4	254	3.7
2 Owls Head	27.32	6.3	5.9	47.7	38.0	6.4	254	3.8
2 Owls Head	27.52	6.3	5.9	47.4	38.0	6.4	254	3.8
2 Owls Head	27.77	6.3	5.8	47.1	38.0	6.4	254	3.8
2 Owls Head	27.94	6.3	5.8	46.8	38.0	6.4	254	3.9
2 Owls Head	28.09	6.3	5.7	46.0	38.0	6.4	254	4.0
2 Owls Head	28.33	6.3	5.6	45.6	38.0	6.4	254	4.1
2 Owls Head	28.65	6.3	5.6	45.3	38.0	6.3	254	4.1
2 Owls Head	28.94	6.3	5.6	45.0	39.0	6.3	255	4.1
2 Owls Head	29.25	6.3	5.4	43.8	39.0	6.3	255	4.1
2 Owls Head	29.50	6.3	5.4	43.2	39.0	6.3	255	4.2
2 Owls Head	29.67	6.3	5.3	42.7	39.0	6.3	255	4.3
2 Owls Head	29.79	6.3	5.2	42.3	39.0	6.3	255	4.3
2 Owls Head	29.90	6.3	5.1	41.5	39.0	6.3	255	4.3
2 Owls Head	30.04	6.3	5.1	40.8	39.0	6.3	255	4.4
2 Owls Head	30.18	6.3	5.0	40.2	39.0	6.3	256	4.5
2 Owls Head	30.30	6.3	4.9	39.5	39.0	6.3	256	4.6
2 Owls Head	30.38	6.2	4.8	38.6	39.0	6.3	256	4.6

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
2 Owls Head	30.46	6.2	4.7	38.1	39.0	6.3	256	4.6
2 Owls Head	30.57	6.2	4.7	37.8	39.0	6.3	256	4.6
2 Owls Head	30.66	6.2	4.6	37.5	39.0	6.3	256	4.8
2 Owls Head	30.76	6.2	4.6	37.0	39.0	6.3	256	5.0
2 Owls Head	30.87	6.2	4.5	36.6	39.0	6.3	256	5.1
2 Owls Head	30.96	6.2	4.5	36.3	40.0	6.3	256	5.2
2 Owls Head	31.06	6.2	4.4	35.9	40.0	6.2	256	5.3
2 Owls Head	31.15	6.2	4.4	35.5	40.0	6.2	256	5.4
2 Owls Head	31.20	6.2	4.4	35.4	40.0	6.2	256	5.4
2 Owls Head	31.28	6.2	4.4	35.3	40.0	6.2	256	5.4
2 Owls Head	31.39	6.2	4.4	35.2	40.0	6.2	256	5.4
2 Owls Head	31.51	6.2	4.3	35.0	40.0	6.2	256	5.4
2 Owls Head	31.63	6.2	4.3	34.8	40.0	6.2	256	5.4
2 Owls Head	31.78	6.2	4.3	34.7	40.0	6.2	256	5.6
2 Owls Head	31.97	6.2	4.3	34.6	40.0	6.2	256	5.9
2 Owls Head	32.24	6.2	4.2	33.9	40.0	6.2	256	6.1
2 Owls Head	32.40	6.2	4.1	33.2	40.0	6.2	256	6.3
2 Owls Head	32.53	6.2	4.0	32.1	40.0	6.2	257	6.5
2 Owls Head	32.61	6.2	3.8	31.0	41.0	6.2	256	6.8
2 Owls Head	32.74	6.2	3.6	29.2	41.0	6.2	256	7.0
3 East End	0.08	22.6	8.5	97.7	38.0	7.1	213	1.7
3 East End	0.16	22.6	8.5	97.8	38.0	7.1	213	1.7
3 East End	0.30	22.6	8.5	97.9	38.0	7.1	213	1.7
3 East End	0.46	22.6	8.5	98.0	38.0	7.1	214	1.7
3 East End	0.73	22.6	8.5	98.0	38.0	7.1	214	1.7
3 East End	1.00	22.6	8.5	98.0	38.0	7.1	214	1.6
3 East End	1.20	22.6	8.5	98.0	38.0	7.1	214	1.7
3 East End	1.45	22.6	8.5	98.1	38.0	7.2	214	1.6
3 East End	1.59	22.5	8.5	98.2	38.0	7.2	214	1.6
3 East End	1.71	22.5	8.5	98.3	38.0	7.2	214	1.6

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
3 East End	1.84	22.5	8.5	98.5	38.0	7.2	214	1.6
3 East End	2.03	22.5	8.5	98.2	38.0	7.2	214	1.6
3 East End	2.22	22.5	8.5	98.4	38.0	7.2	214	1.6
3 East End	2.39	22.5	8.5	98.5	38.0	7.2	214	1.6
3 East End	2.54	22.5	8.5	98.5	38.0	7.2	214	1.5
3 East End	2.71	22.5	8.6	98.8	38.0	7.2	214	1.5
3 East End	2.82	22.5	8.6	98.8	38.0	7.2	215	1.4
3 East End	3.02	22.5	8.5	98.5	38.0	7.2	215	1.4
3 East End	3.15	22.5	8.5	98.6	38.0	7.2	215	1.4
3 East End	3.23	22.5	8.6	98.9	38.0	7.2	215	1.3
3 East End	3.29	22.5	8.5	98.6	38.0	7.2	215	1.4
3 East End	3.40	22.5	8.6	99.2	38.0	7.2	215	1.4
3 East End	3.50	22.5	8.5	98.6	38.0	7.2	215	1.4
3 East End	3.62	22.5	8.6	98.8	38.0	7.2	215	1.4
3 East End	3.79	22.5	8.6	99.1	38.0	7.2	215	1.4
3 East End	3.91	22.5	8.5	98.6	38.0	7.2	215	1.4
3 East End	4.08	22.5	8.5	98.5	38.0	7.2	215	1.4
3 East End	4.26	22.4	8.5	98.3	38.0	7.2	216	1.4
3 East End	4.44	22.4	8.6	98.6	38.0	7.2	216	1.4
3 East End	4.69	22.4	8.5	98.4	38.0	7.2	216	1.4
3 East End	4.91	22.4	8.5	98.3	38.0	7.2	216	1.4
3 East End	5.13	22.4	8.5	98.2	38.0	7.2	216	1.4
3 East End	5.39	22.4	8.5	97.9	38.0	7.2	216	1.4
3 East End	5.63	22.4	8.6	98.8	38.0	7.2	216	1.4
3 East End	5.97	22.3	8.6	98.4	38.0	7.3	217	1.4
3 East End	6.18	22.3	8.5	97.9	38.0	7.3	217	1.4
3 East End	6.36	22.3	8.5	97.9	38.0	7.3	217	1.4
3 East End	6.52	22.3	8.5	97.2	38.0	7.3	218	1.4
3 East End	6.66	22.3	8.4	96.9	38.0	7.3	218	1.4
3 East End	6.82	22.2	8.5	97.1	38.0	7.3	218	1.3

Site	Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity @ 25°C (uS/cm)	pH	Oxidation Reduction Potential	Turbidity (NTU)
3 East End	7.07	22.2	8.5	97.2	38.0	7.3	218	1.3
3 East End	7.30	22.2	8.5	97.2	38.0	7.3	218	1.4
3 East End	7.53	22.1	8.5	97.2	38.0	7.3	218	1.4
3 East End	7.72	21.8	8.6	97.6	38.0	7.3	219	1.4
3 East End	7.99	21.5	8.8	99.8	38.0	7.3	219	1.3
3 East End	8.17	21.3	9.1	102.4	38.0	7.3	219	1.3
3 East End	8.32	20.9	9.4	104.8	38.0	7.3	219	1.2
3 East End	8.52	19.6	10.0	108.8	37.0	7.3	219	1.2
3 East End	8.70	17.7	10.8	113.1	37.0	7.3	220	1.2
3 East End	8.81	17.1	11.9	123.3	37.0	7.3	220	1.2
3 East End	8.95	16.6	12.2	125.0	37.0	7.3	220	1.2
3 East End	9.10	15.9	12.5	126.7	37.0	7.3	220	1.2
3 East End	9.21	15.5	12.8	127.8	37.0	7.3	220	1.2
3 East End	9.32	15.1	12.8	127.5	37.0	7.3	220	1.2
3 East End	9.42	14.8	12.9	127.3	37.0	7.3	220	1.2
3 East End	9.43	14.5	12.9	126.6	37.0	7.3	220	1.2
3 East End	9.46	14.4	12.9	126.7	36.0	7.3	219	1.2
3 East End	9.60	14.2	12.9	125.8	36.0	7.4	219	1.2
3 East End	9.80	13.8	12.9	124.2	36.0	7.4	220	1.3
3 East End	9.97	13.3	12.9	123.5	36.0	7.4	221	1.3
3 East End	10.12	12.9	13.0	122.7	36.0	7.4	221	1.3
3 East End	10.37	12.6	12.8	120.6	36.0	7.4	222	1.4
3 East End	10.56	12.2	12.8	119.6	36.0	7.4	223	1.4
3 East End	10.72	11.9	12.9	119.1	36.0	7.4	224	1.3
3 East End	10.89	11.6	12.9	118.1	36.0	7.3	225	1.3
3 East End	11.10	11.3	12.8	116.4	36.0	7.3	226	1.3
3 East End	11.33	11.0	12.7	115.0	36.0	7.3	228	1.3
3 East End	11.60	10.7	12.5	112.6	36.0	7.3	230	1.4
3 East End	11.81	10.4	12.4	110.4	36.0	7.3	232	1.4
3 East End	12.03	10.1	12.0	107.0	36.0	7.3	233	1.5

Site	Depth	Temperature	Dissolved Oxygen	Dissolved Oxygen	Specific Conductivity @ 25°C	pH	Oxidation Reduction Potential	Turbidity
	(meters)	(°C)	(mg/L)	(% saturation)	(uS/cm)			(NTU)
3 East End	12.19	10.0	11.9	105.1	36.0	7.3	235	1.5
3 East End	12.32	9.8	11.7	102.9	36.0	7.3	237	1.5
3 East End	12.40	9.8	11.5	101.4	36.0	7.3	238	1.5
3 East End	12.49	9.7	11.3	99.6	37.0	7.2	239	2.3
3 East End	12.58	9.7	11.3	98.9	37.0	7.2	240	2.1
3 East End	12.70	9.6	11.1	97.6	37.0	7.2	241	1.9
3 East End	12.87	9.5	11.0	96.5	37.0	7.2	243	1.8
3 East End	12.99	9.4	10.7	93.7	37.0	7.2	244	1.8
3 East End	13.07	9.3	10.6	92.2	37.0	7.2	246	1.9
3 East End	13.12	9.2	10.4	90.1	37.0	7.1	247	2.0
3 East End	13.19	9.2	10.2	88.6	37.0	7.1	248	1.9
3 East End	13.28	9.2	9.9	86.2	37.0	7.1	249	2.1
3 East End	13.35	9.1	9.9	85.4	37.0	7.1	250	2.1
3 East End	13.40	9.1	9.8	84.7	37.0	7.1	251	2.1
3 East End	13.45	9.1	9.7	83.9	37.0	7.0	251	2.3
3 East End	13.51	9.0	9.5	81.9	37.0	7.0	252	2.3
3 East End	13.55	9.0	9.4	81.0	37.0	7.0	252	2.3
3 East End	13.57	9.0	9.3	80.1	37.0	7.0	253	2.5
3 East End	13.57	8.9	9.2	79.0	37.0	7.0	253	2.4
3 East End	13.58	8.9	8.9	77.3	37.0	6.9	254	2.4
3 East End	13.59	8.9	8.9	76.7	37.0	6.9	254	2.4
3 East End	13.62	8.9	8.9	76.4	37.0	6.9	255	2.4
3 East End	13.66	8.9	8.8	76.1	37.0	6.9	255	2.7
3 East End	13.69	8.9	8.7	75.2	37.0	6.9	255	2.9
3 East End	13.73	8.9	8.6	74.4	37.0	6.9	256	6.2
3 East End	13.76	8.9	8.5	73.6	37.0	6.8	256	6.0
3 East End	13.76	8.9	8.4	72.7	37.0	6.8	256	5.3
3 East End	13.77	8.9	8.3	71.3	37.0	6.8	256	4.7
3 East End	13.77	8.9	8.2	70.7	37.0	6.8	256	4.2
3 East End	13.77	8.9	8.2	70.4	37.0	6.8	257	8.0

Site	Depth	Temperature	Dissolved Oxygen	Dissolved Oxygen	Specific Conductivity @ 25°C	pH	Oxidation Reduction Potential	Turbidity
	(meters)	(°C)	(mg/L)	(% saturation)	(uS/cm)			(NTU)
3 East End	13.77	8.9	8.1	70.2	37.0	6.8	257	4.1
3 East End	13.77	8.9	8.1	69.9	37.0	6.7	257	6.1
3 East End	13.76	8.9	8.1	69.7	37.0	6.7	257	5.3
3 East End	13.76	8.9	8.1	69.4	37.0	6.7	257	5.3

APPENDIX B

GLOSSARY OF LIMNOLOGICAL TERMS

Aerobe- Organisms requiring oxygen for life. All animals, most algae and some bacteria require oxygen for respiration.

Algae- See phytoplankton.

Alkalinity- Total concentration of bicarbonate and hydroxide ions (in most lakes).

Anaerobe- Organisms not requiring oxygen for life. Some algae and many bacteria are able to respire or ferment without using oxygen.

Anoxic- A system lacking oxygen, therefore incapable of supporting the most common kind of biological respiration, or of supporting oxygen-demanding chemical reactions. The deeper waters of a lake may become anoxic if there are many organisms depleting oxygen via respiration, and there is little or no replenishment of oxygen from photosynthesis or from the atmosphere.

Benthic- Referring to the bottom sediments.

Bacterioplankton- Bacteria adapted to the "open water" or "planktonic" zone of lakes, adapted for many specialized habitats and include groups that can use the sun's energy (phytoplankton), some that can use the energy locked in sulfur or iron, and others that gain energy by decomposing dead material.

Bicarbonate- The most important ion (chemical) involved in the buffering system of New Hampshire lakes.

Buffering- The capacity of lakewater to absorb acid with a minimal change in the pH. In New Hampshire the chemical responsible for buffering is the bicarbonate ion. (See pH.)

Chloride- One of the components of salts dissolved in lakewater. Generally the most abundant ion in New Hampshire lakewater, it may be used as an indicator of raw sewage or of road salt.

Chlorophyll a- The main green pigment in plants. The concentration of chlorophyll *a* in lakewater is often used as an indicator of algal abundance.

Circulation- The period during spring and fall when the combination of low water temperature and wind cause the water column to mix freely over its entire depth.

Density- The weight per volume of a substance. The more dense an object, the heavier it feels. Low-density liquids will float on higher-density liquids.

Dimictic- The thermal pattern of lakes where the lake circulates, or mixes, twice a year. Other patterns such as polymictic (many periods of circulation per year) are uncommon in New Hampshire. (See also meromictic and holomictic).

Dystrophy- The lake trophic state in which the lakewater is highly stained with humic acids (reddish brown or yellow stain) and has low productivity. Chlorophyll *a* concentration may be low or high.

Epilimnion- The uppermost layer of water during periods of thermal stratification. (See lake diagram).

Eutrophy- The lake trophic state in which algal production is high. Associated with eutrophy is low Secchi Disk depth, high chlorophyll *a*, and high total phosphorus. From an esthetic viewpoint these lakes are "bad" because water clarity is low, aquatic plants are often found in abundance, and cold-water fish such as trout and salmon are usually not present. A good aspect of eutrophic lakes is their high productivity in terms of warm-water fish such as bass, pickerel, and perch.

Free CO2- Carbon dioxide that is not combined chemically with lake water or any other substances. It is produced by respiration, and is used by plants and bacteria for photosynthesis.

Holomixis- The condition where the entire lake is free to circulate during periods of overturn. (See meromixis.)

Humic Acids- Dissolved organic compounds released from decomposition of plant leaves and stems. Humic acids are red, brown, or yellow in color and are present in nearly all lakes in New Hampshire. Humic acids are consumed only by fungi, and thus are relatively resistant to biological decomposition.

Hydrogen Ion- The "acid" ion, present in small amounts even in distilled water, but contributed to rain-water by atmospheric processes, to ground-water by soils, and to lakewater by biological organisms and sediments. The active component of "acid rain". See also "pH" the symbolic value inversely and exponentially related to the hydrogen ion.

Hypolimnion- The deepest layer of lakewater during periods of thermal stratification. (See lake diagram)

Lake- Any "inland" body of relatively "standing" water. Includes many synonyms such as ponds, tarns, loches, billabongs, bogs, marshes, etc.

Lake Morphology- The shape and size of a lake and its basin.

Littoral- The area of a lake shallow enough for submerged aquatic plants to grow.

Meromixis- The condition where the entire lake fails to circulate to its deepest points; caused by a high concentration of salt in the deeper waters, and by peculiar landscapes (small deep lakes surrounded by hills and/or forests. (Contrast holomixis.)

Mesotrophy- The lake trophic state intermediate between oligotrophy and eutrophy. Algal production is moderate, and chlorophyll *a*, Secchi Disk depth, and total phosphorus are also moderate. These lakes are esthetically "fair" but not as good as oligotrophic lakes.

Metalimnion- The "middle" layer of the lake during periods of summer thermal stratification. Usually defined as the region where the water temperature changes at least one degree per meter depth. Also called the thermocline.

Mixis- Periods of lakewater mixing or circulation.

Mixotrophy- The lake condition where the water is highly stained with humic acids, but algal production and chlorophyll *a* values are also high.

Oligotrophy- The lake trophic state where algal production is low, Secchi Disk depth is deep, and chlorophyll *a* and total phosphorus are low. Esthetically these lakes are the "best" because they are clear and have a minimum of algae and aquatic plants. Deep oligotrophic lakes can usually support cold-water fish such as lake trout and land-locked salmon.

Overturn- See circulation or mixis

pH- A measure of the hydrogen ion concentration of a liquid. For every decrease of 1 pH unit, the hydrogen ion concentration increases 10 times. Symbolically, the pH value is the "negative logarithm" of the hydrogen ion concentration. For example, a pH of 5 represents a hydrogen ion concentration of 10^{-5} molar. [Please thank the chemists for this lovely symbolism -- and ask them to explain it in lay terms!] In any event, the higher the pH value, the lower the hydrogen ion concentration. The range is 0 to 14, with 7 being neutral 1 denoting high acid condition and 14 denoting very basic condition.

Photosynthesis- The process by which plants convert the inorganic substances carbon dioxide and water into organic glucose (sugar) and oxygen using sunlight as the energy source. Glucose is an energy source for growth, reproduction, and maintenance of almost all life forms.

Phytoplankton- Microscopic algae which are suspended in the "open water" zone of lakes and ponds. A major source of food for zooplankton. Common examples include: diatoms, euglenoids, dinoflagellates, and many others. Usually included are the blue-green bacteria.

Parts per million- Also known as "ppm". This is a method of expressing the amount of one substance (solute) dissolved in another (solvent). For example, a solution with 10 ppm of oxygen has 10 pounds of oxygen for every 999,990 pounds (500 tons) of water. Domestic sewage usually contains from 2 to 10 ppm phosphorus.

Parts per billion- Also known as "ppb". This is only 1/1000 of ppm, therefore much less concentrated. As little as 1 ppb of phosphorus will sustain growth of algae. As little as 10 ppb phosphorus will cause algal blooms! Think of the ratio as 1 milligram (1/28000 of an ounce) of phosphorus in 25 barrels of water (55 gallon drums)! Or, 1 gallon of septic waste diluted into 10,000 gallons of lakewater. It adds up fast!

Plankton- Community of microorganisms that live suspended in the water column, not attached to the bottom sediments or aquatic plants. See also "bacterioplankton" (bacteria), "phytoplankton" (algae) and "zooplankton" (microcrustaceans and rotifers).

Saturated- When a solute (such as water) has dissolved all of a substance that it can. For example, if you add table salt to water, a point is reached where any additional salt fails to dissolve. The water is then said to be saturated with table salt. In lakewater, gaseous oxygen can dissolve, but eventually the water becomes saturated with oxygen if exposed sufficiently long to the atmosphere or another source of oxygen.

Specific Conductivity- A measure of the amount of salt present in lakewater. As the salt concentration increases, so does the specific conductivity (electrical conductivity).

Stratum- A layer or "blanket". Can be used to refer to one of the major layers of lakewater such as the epilimnion, or to any layers of organisms or chemicals that may be present in a lake.

Thermal Stratification- The process by which layers are built up in the lake due to heating by the sun and partial mixing by wind.

Thermocline- Region of temperature change. (See metalimnion.)

Total Phosphorus- A measure of the concentration of phosphorus in lakewater. Includes both free forms (dissolved), and chemically combined form (as in living tissue, or in dead but suspended organisms).

Trophic Status- A classification system placing lakes into similar groups according to their amount of algal production. (See Oligotrophy, Mesotrophy, Eutrophy, Mixotrophy, and Dystrophy for definitions of the major categories)

Z- A symbol used by limnologists as an abbreviation for depth.

Zooplankton- Microscopic animals in the planktonic community. Some are called "water fleas", but most are known by their scientific names. Scientific names include: *Daphnia*, *Cyclops*, *Bosmina*, and *Kellicottia*.